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DAVID HUNT LINDER

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Men of science turn instinctively from the path of least resistance so plainly marked by the signposts of emotional reactions. David Linder was first of all a scientist, outstanding in his ability as one of the leading mycologists of his time. True to his science his work shows an ingrained distrust of purely emotional responses. His fellow mycologists, however, in weighing the promise of a life but partially fulfilled cannot do so in the cold dispassionate balances of the laboratory. The still-felt warmth of his sincere, friendly and responsive personality makes foolish any attempt to exclude a deep feeling of loss through his untimely death. A brief sketch of his life and work as a mycologist and a review of his trusteeship as Curator of the Farlow Herbarium and Reference Library at Harvard University should refresh the memories of fellow-workers who were close to him and, for those not fortunate enough to have known him well, should turn a bright page in the history of botanical science.

David Hunt Linder was born in Brookline, Massachusetts, September 24, 1899. Most of his early childhood, however, was spent in the rural town of Canton. His early opportunities for observation of Nature made indelible impressions that time intensified. David Linder's parents did much to foster a love of plant life in their children; indeed, his father was more in love with botany and horticulture than with his profession as a chemist.

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The Linder home in Canton had, besides a conservatory, a greenhouse and extensive gardens of flowers and vegetables, a considerable acreage of wild and cultivated shrubs and trees. The influence of that ideal situation remained with David Linder all of his life.

There was a typical country schoolhouse near the Linders' on York Street in Canton where David and his brothers went for a year or two. In later years they referred to it with affectionate hyperbole as "York University." Leaving the little schoolhouse David Linder went to Noble and Greenough School for Boys, at Dedham, Massachusetts, to complete his basic education. He entered Harvard College in 1917 and as an undergraduate passed the period of World War I in the S.A.T.C. with a limited chance to assist the war effort in chemistry and a brief but long-remembered acquaintance with "close-order drill." A mild distaste for the military mind, expressed during the recent world conflict, was attributable to the sergeant who guided the erring feet of his unit in the paths of military righteousness.

Receiving his A.B. from Harvard College in 1921 he applied himself to graduate study in his chosen field of mycology. This was from no sudden whim for, in addition to encouragement he received from his father, he was also much indebted to his great-uncle, William Gilson Farlow, for guidance. Dr. Farlow died while David Linder was an undergraduate; nevertheless there are letters to show that they exchanged ideas regarding the identity of fungi even before David Linder entered college. He often told of visits to his uncle's home in Cambridge and of vacation trips to the summer home near Mt. Chocorua in New Hampshire where Dr. Farlow found him eager for initiation into the mysteries of mycology.

When David Linder had completed his undergraduate studies Mrs. Farlow, realizing that a bit of encouragement is of great value to a young man in getting started in his chosen field, very generously helped to finance part of a trip to Europe and the British Isles. David Linder learned much and made many valuable friends on his visit. Friendships thus formed continued through the years via correspondence and the visits of his European friends to this country.

After receiving his M.A. degree in 1922 he was granted a Sheldon Travelling Fellowship on which he visited British and Dutch Guiana and parts of the British West Indies. This trip gave David Linder a love of the tropics that he carried with him the rest of his life. When, in 1926, upon completion of his requirements for a Ph.D. at Harvard he had an opportunity to go with the Harvard African Expedition to Liberia he jumped at the chance. The going was tough in the jungle and he never fully recovered from the physical strain. To him, however, it was more important that he had once again visited the tropics.

Upon his return from Africa he went to St. Louis, Missouri, as instructor in the Henry Shaw School of Botany at George Washington University and as Mycologist on the staff of the Missouri Botanic Garden. By 1928 he had become Assistant Professor of Botany, retaining the position of Mycologist at the Garden. While working in St. Louis he married Elinor Alberts who served on the staff of the Garden as Orchidologist and later brought her orchid collection to Canton, Massachusetts, when, in response to a lengthy and stimulating correspondence with Professor Weston, David Linder returned to Harvard as instructor in cryptogamic botany in 1931.

While at Missouri his relationship with the director, Prof. G. T. Moore, and the members of his staff was most cordial. He enjoyed all but the teaching. The unfortunate part of the teaching was that although in any informal discussion he was entirely at ease, when "lecturing" he often suffered genuine anguish.

In spite of his repugnance for formal speaking he addressed many science meetings, though the list of societies of which he was a member was more choice than lengthy. He was a charter member of the American Mycological Society of which he was Secretary-Treasurer in 1936–38, Vice-President in 1939 and President in 1940; he was a Fellow of the American Association for the Advancement of Science, Secretary of the Society of Plant Taxonomists, a member of the Torrey Botanical Club, the New England Botanical Club and the British Mycological Society. In American Men of Science his name bears the star that identifies the first thousand men in each major field of science.

While working as Professor Weston's assistant at the Biological Laboratories of Harvard University in 1932 he began his curatorship of the Farlow Herbarium, the same year in which Dr. Thaxter died. This was the year when the economic depression reached its bottom level. Luxury items felt the full effects of a jolted economy and the orchid business established by his first wife was lost.

In 1935 he attended the International Botanical Congress at Amsterdam with Dr. F. J. Seaver. On this trip he reestablished many of the friendships made years before in England and on the Continent. The Congress strengthened his conviction regarding the need for concrete rules of nomenclature in mycology and the importance of strict adherence to such rules.

During the next four years he busied himself more and more with the difficult task of keeping a cryptogamic herbarium and reference library going. His first wife died, whereupon he gave up the family estate in Canton and moved into Cambridge. Characteristically he shared his apartment with a surprising number of graduate students. It was not uncommon to find there nearly a dozen men, mostly mycologists, all of whom will never forget those gatherings.

David Linder was not a man to give way to depression—either mental or economic—but it was with a feeling of relief that his friends learned, in 1939, that he had married again and established a home in Wakefield, Massachusetts. The warm hospitality of the Linder home was opened to a wide circle of friends and acquaintances who were made to feel at ease by the natural charm of his wife, Dorothy, and the delightful atmosphere of informality.

David Linder spent by far the greater part of his life in the academic circle where two men did more than any others to round out his character and to complete his training as a mycologist. Both are outstanding in the field of mycology but beyond that they had very little in common. The first of these, Dr. Roland Thaxter, was rather austere, and somewhat puritanical but with a subdued sense of humor. Since his industry and erudition as the outstanding mycologist of his time were self-evident he was a paramount example for any student. He had little sympathy with mediocrity and none at all with sloppiness. David Linder's myco-

logical drawings attest to the success with which Dr. Thaxter indoctrinated him with his rule of perfection. The other teacher, Dr. Wm. H. Weston, Jr., was the foil for Dr. Thaxter's unbending personality. He too, however, had been a student of Dr. Thaxter's so that for David Linder there was a double-distilled draught of the master-brew of mycological knowledge rendered more palatable by the warmer, approachable nature of Dr. Weston. Nor was Dr. Weston a mere middleman in the deal; he had so much of his own to contribute that he became a guide and mentor within and beyond the limits of their profession. This was quite natural for although Dr. Thaxter could be admired as a great man in his field Dr. Weston was accepted as a companion being but a few years older than David Linder himself. Dr. Weston was largely instrumental in getting him back to Harvard University as Curator of the Farlow Herbarium, to the great benefit of both the Herbarium and the University.

To mycologists the name of David Linder will always be inseparable from the Farlow Herbarium of which he was Curator for fourteen years. He put the collections to work and made them grow in fame and size by his personal effort in a manner that would have won the full approval of William Gilson Farlow.

There are, in round numbers, 980,000 specimens of cryptogams in the cases of the Farlow. Nearly 200,000 of these (about half of them fungi) were added to the collection since 1932. In the same period of time the Herbarium sent out in exchange or for study about 35,000 specimens of fungi and additional other cryptogams to a total of nearly 50,000 specimens. There are still some outgoing and incoming items not accounted for; hence, it is impossible to cite exact figures. There is room enough for astonishment at these rough totals! David Linder maintained the collections for use, not merely for selfish accumulation. He thought of an Herbarium as a Bureau of Standards where the type specimen of a given species serves as a gauge with which to measure others.

Some of the more important cryptogamic collections added to the Herbarium during his curatorship were: the A. M. Scott algae, the Bartholomew fungi, Miss Caroline Hayne's hepatics, his friend Frans Verdoorn's hepatics, the Sprague lichens, Dr. Clar-

ence Cheever's diatoms, Mrs. E. B. Blackford's fungi (including many of Peck's types) and several hundred beautifully executed paintings of higher fungi, also Miss Lizzie Allen's paintings of higher fungi.

As an important adjunct to the dried and preserved material in the herbarium David Linder maintained a living collection of fungi in culture for exchange and study. Of nearly 500 cultures more than 200 were of medical importance.

In the Farlow Library, directly connected with the Herbarium, in 1932 there was reported a combined total of 19,750 books, periodicals, reprints and state or government publications. State and government papers were reported in "volumes" of ten papers each; hence this total actually includes only ten percent of such publications. In spite of the depression, the war, and the generally low state of the Farlow Library exchequer it is encouraging to note that by July, 1946, the total of available items on the shelves had risen to 37,208. The figures show a net increase of 17,458 items during the fourteen years of David Linder's association with the Farlow Library. At the time of his death accessions were at the rate of 1200 per year and did not, so far as possible, duplicate any of the things going to the other libraries of the University. Bare statistics are by no means the whole story. The difficulties encountered in keeping this valuable and important library growing may be read in part in Dr. Linder's annual reports in which he did everything but call down curses on the heads of the Powers That Be to make them see the value of the tools that these books and papers are to the scientist.

Any serious research worker realizes that a library is more than just a collection of books and papers. The items must be reasonably accessible and there must be some system of indexing. Since 1932 there have been added to the shelf-list a total of more than 13,000 author cards and to the subject catalogue more than 26,000 cards. All of these items, so far as possible, refer to authors or works dealing with cryptogamic botany. They are, moreover, additions to a collection of cards, many of them hand-written, that were prepared by Dr. Farlow, Dr. Thaxter and others. Now it is possible for a student to find thousands of items in the literature

in a matter of minutes where formerly it took hours. This was accomplished by Dr. Linder working with a staff that would appear woefully inadequate in numbers in institutions of much less importance and of smaller size than the Farlow Herbarium and Library. It is a tribute to the qualities of leadership and tenacity of purpose exhibited by Dr. Linder that even such apparently minor aspects in the progress of the institution were at no time neglected.

During 1939 a catalogue was started that is unique in the annals of cryptogamic botany and of special value to those interested in the personalities that developed the field. Dr. Linder, with the help of Miss Harris, the librarian, has assembled a card index of 2,335 pictures of botanists ranging from group photographs to formal portraits, including 1,588 individuals and 747 duplications.

David Linder often spoke of the need for monographic studies in mycology. In 1943, in the first number of Farlowia came the realization of the kind of journal he had in mind as a vehicle for monographic articles. He was very largely instrumental in its publication and, as editor-in-chief, in his foreword to the first number, he said . . . "most journals are published by academies, societies or institutions which for the most part must limit the privilege of publication to their members. . . . To remedy this situation and to make possible the publication of longer taxonomic papers it has been decided to publish (Farlowia) . . . which . . . will include articles up to one hundred pages in length and that deal with . . . the classification of the non-vascular cryptogams." Thus was launched a quarterly journal, a valued companion publication to Mycologia and a memorial both to William Gilson Farlow and to his distinguished grand-nephew and successor, David Linder.

In the Report of the President of Harvard University, 1935–36, Dr. Linder wrote, "As matters stand today, the only two members of the staff who are trained to do scientific work and publication are burdened with routine work. . . . Under such conditions it is impossible for the staff to publish papers . . . since only the briefest papers may be put together in the occasional scattered moments that are available for research. . . ." These same words could still have been used ten years later. Indeed, he did use al-

most identical words each year in pleas for more funds and more time for study. It is a matter of pride to botanists, however, that the list of publications of which David Linder was the author or co-author in the years since 1936 shows how well those "occasional scattered moments" for research were used. He always looked forward to budgets commensurate with the endeavor they support and to hours of study to free capable men from the petty cares of counting-house clerking. It is noteworthy that in all of his pleas for time and funds his first thought was for the furtherance of science and the helping of *other* scientists.

While David Linder was curator the Farlow Herbarium produced almost an even one hundred and fifty scientific papers contributing to the knowledge of cryptogamic plants, principally the fungi. Of this impressive number he was personally credited with nearly one-fourth. This is the more remarkable when the burden of administrative duties is considered, and when it is realized that he had virtually no stenographic assistance in an extensive correspondence, and that he was continually busy with the identification of specimens sent to the herbarium. As if these duties were not burdensome enough to have consumed the time of two less energetic men he added to them the teaching of courses, the preparation of papers delivered at meetings of the Mycological Society, and the special instruction of many graduate students, who, in a number of cases, were not assigned to him but who, once having received help or advice, kept coming back to the one upon whom they learned to depend as an unfailing source of help in any matters pertaining to the fungi. Where then did he find the time for his beautifully executed drawings? In these extraordinarily well-wrought illustrations he carried on the tradition of the Harvard Cryptogamic Laboratories as established by the brilliant work of Roland Thaxter.

As a mycologist David Linder explored many parts of a broad field and acquired a perspective denied to many specialists. He pioneered in several unrelated branches of mycology. His "Monograph on the Helicosporous *Fungi Imperfecti*" was, to a large extent, pioneering and, backed by his subsequent contributions to this fascinating hinterland of the fungous world, he expanded consider-

ably the arc of a hitherto much restricted mycological horizon. When he made a study of the marine fungi (with E. J. Barghoorn) he found himself literally in uncharted mycological waters where the taxonomic problems would have dismayed a less capable man. A posthumous paper on the fungi of the Canadian Sub-Arctic will show the pioneering urge still carrying him toward new horizons of mycological knowledge.

Bare statistics tell but little, yet there are not many men who in less than a quarter century, in addition to duties that many might consider full-time work in themselves, could ferret out, describe, compare, measure, draw, and establish one new family of fungi, sixteen new genera, and one hundred seventy new species or combinations. Here indeed was a young man to refute the pessimism of those who see no good except in the dim past. By his example David Linder has shown the men of the coming generation what can be done.

He was intensely patriotic in the best sense of the word and proved his patriotism handsomely in the recent world conflict as a citizen and as a mycologist. Many mycologists will remember that in his address as retiring President of the Mycological Society he opened on a patriotic note when he urged the members of the Society . . . "as mycologists . . . to serve our country . . . and still continue to add to the knowledge of our subject. . . ." This admonition preceded the Japanese attack on Pearl Harbor and our entry into the war by several months.

His own contribution was made at considerable self-sacrifice at a time when he suffered a good deal of illness. For his work the U. S. Quartermaster Corps was more than grateful. Dr. Weston who was closely associated with him in that work will do full justice to the subject in a forthcoming paper in Farlowia.

It is recommended that members of the Mycological Society reread David Linder's address as retiring President of the Society. In addition to his expression of patriotism there is a good deal else in the address that gives additional insight into David Linder, the mycologist. He discussed the value of taxonomic mycology to keep the plant pathologist, the medical mycologist and others from the brink of nomenclatorial chaos. He defended Latin diagnoses,

not that he believed the International Rules immutable just because they are *rules,* but rather that they should be followed strictly until such time as they might be changed by due process of law rather than by whim.

David Linder's published works, representing in part his contribution to the science of cryptogamic botany, will stand as an enduring memorial to his name.

U. S. DEPARTMENT OF AGRICULTURE,
206 FEDERAL BLDG.,
CAMBRIDGE 39, MASSACHUSETTS,
DECEMBER, 1946

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PRODUCTION OF TELIOSPORES AND UREDOSPORES OF PUCCINIA GRAMINIS ON BERBERIS CRETICA IN NATURE *

P. D. Critopoulos

(with 1 figure)

The black stem rust occurs annually on the cereals in Greece and sometimes it is very severe. The alternate host of this rust is *Berberis cretica* which is the only species of the family *Berberidaceae* growing wild in this country. Its habitat is on mountains from 800 m. to subalpine regions in Macedonia, Thessaly, Eubœa, Attica, Laconia, and Crete. *Berberis cretica* is annually attacked by *P. graminis;* however, so far it has not been proved that it plays an indispensable part in the life cycle of the black stem rust. If the bush formation of this alternate host on the mountain tops is really a source of inoculum for the cereals in the plains, then a program of eradication would have to be considered. This problem however is not answered in the present paper. Instead an interesting fact is recorded, namely, the finding of teliospores and urediospores of black stem rust on the alternate host. In this connection I desire to give due recognition for guidance to my honored Professor Frank D. Kern of the Pennsylvania State College, U. S. A.

The infection of *B. cretica* by *P. graminis* has been known for a long time. Stakman (**1923**) was one of the first to mention it. Politis (**1929**) also found *B. cretica* infected by the black stem rust of cereals. On the contrary, in west and south Asia Minor the same barberry, which forms more or less extensive formations on the mountains above the tree zone, *i.e.* over 1500 m., has not been found to be attacked. On the leaves the infection consists of yellowish spots one or more on each leaf, in the middle of which first pycnia and then aecia are produced. On the diseased fruits the at-

* Presented to the Mycological Society of America (by Frank D. Kern for the author) at the St. Louis meeting, March 27, 1946.

tack is always severe, the whole surface being covered by aecial cups. Young stems and spines are also attacked. Likewise the short flower and leaf bearing twigs are infected and then all their parts become smaller, thicker, and distorted, being covered all over by aecia.

The swelling of the diseased parts of the leaves is due to the multiplication and enlargement of the parenchyma cells. In the normal portion of the leaf blade there is only one layer of palisade cells, whereas in the swollen portion there are two or three of these rows. In the parenchyma cells there are oil globules and these are considered to indicate full maturity and exhaustion. The attacked leaves fall from the bushes about the middle of July or in the beginning of August. In wet situations as for example along brooks, the infected leaves may remain on the bushes for a longer time.

Pycnia are formed in the middle of the yellow spots both on the upper and on the lower sides of the leaf blade. Aecia are formed in the middle or scattered all around the yellow spots on the under surface of the blade; often, however, they are found on the corresponding position on the upper surface. The early-developed aecia differ somewhat from those that develop later. The early ones attain a length of 0.2–0.5 mm. and open very soon, whereas the later ones have a length of 1.5–2 mm. and a diameter of 0.1–0.3 mm. The late-appearing aecia are found at the periphery and sometimes they form a row round about the aecia which were produced first; they can be considered as secondary in the same way as in certain instances there are secondary uredia around the primary uredium in the cereals. The aecia which develop late attain their full size during the early part of July. At the bottom and at the top they are somewhat narrower. Often they reach their full length and then the peridium breaks open at the top. The aeciospores are 15–18 × 18–24 μ with finely verrucose walls. The upper side of the wall of the aeciospores sometimes is one-third of the diameter of the spore. Other times it is less than one-third, or it is not evenly thickened, or the thickness may be represented by an internal roundish projection, or it may be thick and at the same time have a projection which reaches to the center of the spore.

In the fully developed aeciospores the orange colored granular

content fuses gradually, after about ten days, to bigger particles or forms one big mass. When this occurs their infecting power is lost. If the aeciospores are left in a drop of water in the light, the oily substance loses its orange color in about half an hour, becoming colorless or light grayish-green. It is interesting that in the rows of aeciospores in the aecia, the carotinoids exist in normal proportion in a certain spore, the next spore toward the inside of the cup is entirely colorless. As generally happens with uredia and aecia, the spores in the latter become smaller and their walls attain greater thickness.

The peridial cells have their outer wall 12–14 μ thick which is one-half, or sometimes more, of the radial diameter of the cell. The inner wall is 3–4 μ thick. The walls of the peridium have dark parallel straight lines corresponding with the walls of two adjacent cells. On the outer wall the dark lines are directed toward the outside. Both on the outside and inside the dark lines end in the projecting small protuberances. The inner protuberances in comparison to the outer are somewhat larger. It is supposed that these dark lines are moisture conducting channels. The content of the peridial cells is colored like that of the aeciospores.

The telia are not very abundant. One has to look over many diseased leaves in order to find one. They occur at the edge of the infected yellow spots, on the upper or on the lower side of the leaf blade, or on the other infected plant parts. When covered the telia are blackish brown, when they rupture they are black. They are fairly compact. In form they are more or less round, and about 0.3 mm. in diameter. The telia are formed in the middle of July, just before the leaves fall from the bushes.

The teliospores (FIG. 1) are ellipsoid or oblong-clavate, 18–26 × 34–61 μ, narrowed or rounded above and below, somewhat constricted at the septum, the walls are chesnut-brown, paler below, about 1.5 μ thick at the sides, 5–9 μ above, the pedicels are about as long as the spore. There are also mesospores. The telia occur in such proximity to the aecia that there can be no doubt about the relationship of the two stages. Separate uredia have not been found but a few urediospores have been observed among the teliospores. The urediospores are 18–20 × 22–40 μ. Those that were observed were colorless. The similarity of the teliospores and

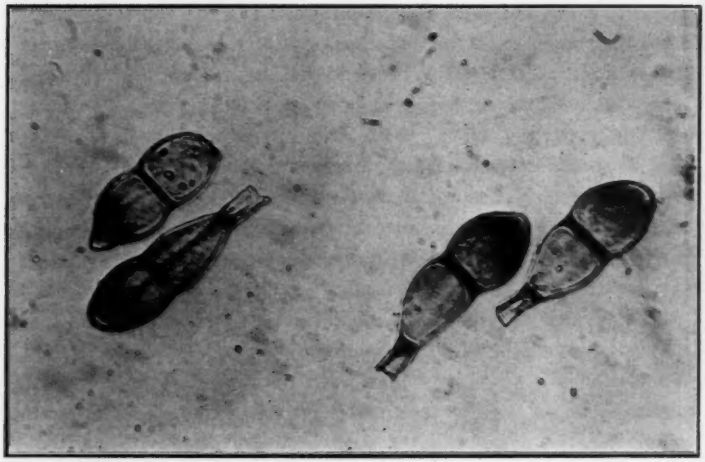

FIG. 1. Teliospores of *Puccinia graminis* produced on *Berberis cretica* in nature.

urediospores with those of *P. graminis* as ordinarily found on the grass hosts is perfect.

Although the finding of teliospores and urediospores on the alternate host is noteworthy, there is a record of an occurrence similar in some respects. Newton and Johnson (**1937**) of the Dominion Rust Research Laboratory, Winnipeg, Canada, report that "In the course of greenhouse studies, in which barberry plants were infected with pure cultures of physiological races of *P. graminis tritici* Erikss. & Henn., we have recently observed that two cultures show a distinct tendency to produce uredia and telia on the barberry." The same authors, in a second publication (**1938**), state that "the production of urediospores and teliospores on the barberry is, perhaps, the most unexpected of the abnormalities described in this paper."

It is interesting that there are some notable differences between the production of the telio- and urediophase on *B. vulgaris* from that on *B. cretica*. On the former, where urediospores and teliospores were produced, pycnia were also produced, but there was always a suppression of aecial formation. This constitutes a brachy-form.

On the latter, pycnia and aecia as well as teliospores and a limited number of urediospores are produced. This constitutes an eu-form. The urediospores produced in the Canadian cultures germinated normally and readily infected wheat seedlings but were apparently unable to infect barberry. Newton and Johnson therefore regarded their strains as still heteroecious. So far as known the present case is the only report of the production of teliospores and urediospores of *P. graminis* on the barberry in nature. The others appeared only in cultures.

In nature there are numerous cases in which a macrocyclic rust (one having the full number of spore-stages) is heteroecious and a microcyclic rust (one which produces pycnia followed shortly by telia or in which pycnia are lacking and only telia are produced) occurs on the aecial host of the heteroecious species with teliospores which are structurally like those of the heteroecious species. Such macrocyclic and microcyclic species are known as *correlated* species. Microcyclic forms may have arisen from the haploid generation of the correlated macrocyclic heteroecious forms through the replacement of the aecia by telia. This view of the origin of the microcyclic forms through reduction from heteroecious macrocyclic forms has been presented by Arthur (**1929**), Jackson (**1931**) and others.

Puccinia coronata, the crown-rust of oats and other grasses, has a correlated microcyclic species, *Puccinia mesnieriana.* It occurs on *Rhamnus* which is the aecial host of *P. coronata.* The teliospores of the two are identical, including the crowned projections at the apex. Johnson and Newton (l.c.) state that Dr. G. R. Bisby in private correspondence has pointed out that, in theory, *Puccinia graminis* might have a correlated species with telia on *Berberis vulgaris.* They say it is possible to theorize that the Canadian developments in culture "may perhaps be considered as a tendency on the part of *P. graminis* towards the formation of such a species." The condition on *Berberis cretica* might be interpreted as a step in this direction.

It should be added that there are several microcyclic species of *Puccinia* known on *Berberis,* five from South America and one from Texas. In none of these are the teliospores like those of *P. gram-*

inis. They are not correlated species and therefore need not enter into the present consideration. There is a distinct macrocyclic heteroecious species in Europe with aecia on *Berberis* and uredia and telia on grasses, *Puccinia Arrhenatheri* (Kleb.) Erikss. Since the aecia, aeciospores, and teliospores of this species are different from those of *Puccinia graminis* it cannot have any relation to the present discussion.

As has been stated, *P. graminis* on *B. cretica* has the life history of an autoecious eu-form. In such a form the teliospores and urediospores might develop from a discontinuous diploid generation originating from an aecial infection. In this case it appears that the teliospores and urediospores have developed from the same mycelium which bore the aecia but the evidence is circumstantial. From a genetic viewpoint the production of telio- and urediospores is inherent in the diploid generation of *P. graminis*. Whether it is necessary to assume a changed genic factor to explain their development on the barberry instead of the grass is not clear.

The unusual production of teliospores and urediospores of *P. graminis* on the alternate host, here reported, although not extensive is nonetheless real. Teliospores of this rust produced on the gramineal host do not sustain their vitality during the long period of heat and dryness in the lower altitudes. These spores kept under natural conditions germinate in the spring only 0.5 per cent. It is therefore considered that the production of telio- and urediophase on the alternate host is more or less a successful adjustment on the part of the fungus to produce all spore forms on a host having its habitat at high altitudes where conditions are comparatively more congenial for the sustaining of the germinating power of teliospores.

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CHYTRIOMYCES SPINOSUS NOV. SP.

DOLORES J. FAY

(WITH 39 FIGURES)

This chytrid was first isolated from a sample of soil collected in the Pine Barrens in Ocean County, N. J., and subsequently found in rich woodland soil from various parts of New Jersey, New York, Connecticut, and Virginia. In isolating this fungus, the common procedure of covering the soil samples with animal charcoal water and adding bits of lens paper as a substratum was followed. After this substratum became heavily infected, the chytrid was transferred to small pieces of onion skin and grown in virtual unifungal culture in fresh charcoal water to which had been added either a small amount of soil from the original culture or soil water which had been put through a Berkfeld filter.

This monocentric, eucarpic species is characterized by extramatrical, rarely apophysate, operculate sporangia; intramatrical rhizoids attached to a small stalk at the base of the sporangium; posteriorly uniflagellate zoospores which swarm in a vesicle after emerging from the sporangium; and extramatrical resting spores. Accordingly, it belongs in the genus *Chytriomyces*.[1] However, unlike other known species of this genus, it is not markedly chitinophilic and grows more readily on carbohydrate substrata. It differs primarily from *C. aureus* and *C. hyalinus* by the presence of numerous sharp, abruptly-tapering spines which are more or less regularly arranged on the surface of the sporangia and resting spores. Because of this characteristic difference, it is interpreted as a new species and named *C. spinosus*.

Chytriomyces spinosus n. sp.

Zoosporangiis hyalinis, plerumque late pyriformibus 11.3–45 × 11.3–40.5 μ; operculo apicali, vadoso figura ad modum patellae 2.3–6 × 0.75–4.5 μ et apicu-

[1] **Karling, J. S.** 1945. Brazilian chytrids. VI. *Rhopalophlyctis* and *Chytriomyces*, two new chitinophilic operculate genera. Am. Jour. Bot. **32**: 362–369.

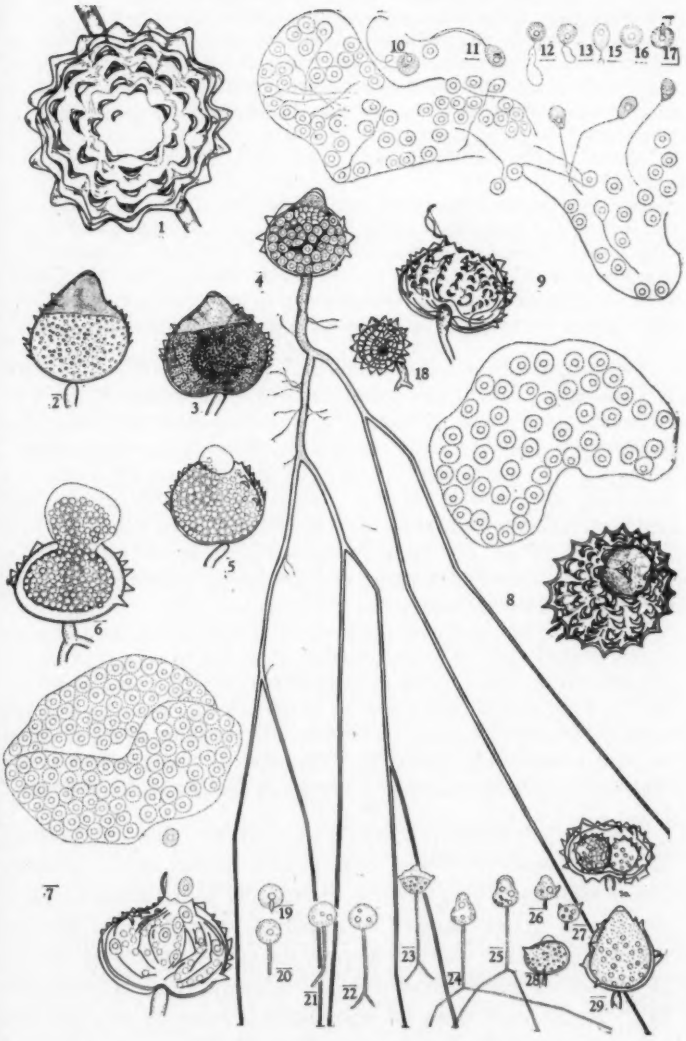

FIG. 1. *Chytriomyces spinosus.*

lato 1.5 × 6.9 μ sporangii pariete 0.75–1.5 μ crassitudine, coopertis plurimus spinis praerupto fastigantibus, generatim simplicibus et solidis 2.5–4.9 × 1.4–5.9 μ raro bifurcatis, aliquando abortivis ad modum paxilli. Rhizoidibus ramosis, generatim emergentibus ab uno principali axi 1.6–3.6 μ diametro et extendentibus longitudine 387 μ. Zoosporis hyalinis, subsphaericalibus 3–4.5 μ parvo medio globulo refractivo hyalino 1.7–2.1 μ diametro; flagello 18–21 μ longitudine. Zoosporis emergentibus et glomerantibus 1–7 punctis temporis in vesiculo hyalino ante effugientibus et enatantibus; vesiculo continuo cum sporangio.

Sporis perdurantibus plerumque ovatis 15–33 × 10–33.5 μ, cuneate 15× 15 μ raro sphaericali; generatim et impariter coopertis spinis simplicibus vel bifurcatis; pariete hyalino vel parum flavo 1.4–4.5 μ crassitudine; continente unicum globulum olei 6.8 ad 21 μ diametro. Sporis perdurantibus in germinatione ut prosporangia agunt, causantibus parietem tenuem hyalinum subsphaericalem sporangiis levibus secundariis 8.9 ad 20.6 μ diametro.

Zoosporangia hyaline, predominantly broadly pyriform, 11.3–45 × 11.3–40.5 μ, operculum apical, shallow saucer-shaped, 2.3–6 × 0.75–4.5 μ, and apiculate 1.5 ×6.9 μ, wall of sporangium 0.75–1.5 μ in thickness, covered with numerous, abruptly tapering spines, usually simple and solid, 2.5–4.9 × 1.4–5.9 μ, rarely bifurcate, occasionally abortive and peg-like. Rhizoids branched, arising usually from a single main axis, 1.6–3.6 μ diameter and extending to a distance of 387 μ. Zoospores emerge and swarm 1–7 minutes in a hyaline vesicle before escaping and swimming away; vesicle continuous with the sporangium.

Resting spores predominantly ovoid and 15–33 × 10–33.5 μ or wedge-shaped and 15 × 15 μ, rarely spherical; usually covered irregularly with spines which may be simple or bifurcate; wall hyaline or slightly yellowish, 1.4–4.5 μ in thickness; containing a single large oil globule 6.8 to 21 μ in diameter. Resting spores function as prosporangia in germination, giving rise to hyaline subspherical thin-walled, smooth secondary sporangia 8.9 to 20.6 μ diameter.

The life cycle and development of *C. spinosus,* shown in FIGS. 2–30, are fundamentally similar to those of *C. aureus* and *C. hyalinus.* The broadly oval zoospore, with its centrally placed refractile globule, comes to rest, absorbs its flagellum (FIGS. 10–12), and develops a germ tube which penetrates the substratum (FIGS. 19, 20, 21), branches and eventually gives rise to the rhizoids (FIGS. 22–25). At the same time, the extramatrical zoospore enlarges and, as nutriment is absorbed by the rhizoids, develops into a sporangium or resting spore. The characteristic spines begin very early as papillae on the wall of the young incipient sporangium (FIGS. 23,

26, 27) and at first appear very large in proportion to the rest of the zoospore body (FIGS. 27, 28, 29). As is shown (FIGS. 1, 8, 9, 29), they occur frequently over the entire surface of the zoosporangium and resting spore except on the rounded basal portions. Sometimes a spine may occur on the operculum. Usually, the spines on the zoosporangia are simple, solid and abruptly tapering, or they may be comparatively long (FIGS. 4, 6). Occasionally, they are abortive, peg-like, or bifurcate. On the resting-spores, the spines may be more finely drawn out at the tip, bifurcate, irregular, blunt, finger-like, or lacking altogether.

The successive internal protoplasmic changes which occur in the development and maturation of the zoosporangia are so like those described for most of the other monocentric eucarpic chytrids that a detailed description of the process is superfluous. However, one exception has been constantly observed which is worthy of mention. During development a large amount of opaque, optically homogeneous, slimy material accumulates in the apex of the sporangium under the operculum (FIGS. 2, 3, 4). The relative amount of this material varies considerably but, in numerous cases, it may be so great that it fills almost half of the sporangium. In such instances, the zoospore initials with their refractive globules appear to be pushed down into the lower part of the sporangium while the upper part appears relatively empty. When the sporangium dehisces, this slimy substance flows out to form a globular mass at the exit orifice (FIG. 7). As the zoospores emerge, they push up into the mass and expand it (FIGS. 5, 6, 7). By the time most of the zoospores have emerged, the slimy material has been expanded to the extent that it consists of a thin layer around the globular zoospore mass. Present observations indicate that as this layer thins out it becomes transformed into a vesicular membrane within which the zoospores subsequently swarm.

Following emergence from the sporangium, the behavior of the zoospores is similar to that described by Karling (l.c.) for *C. aureus* and *C. hyalinus*. As a result of the rapid swarming of the zoospores within, the vesicle changes rapidly in shape (FIGS. 7, 8, 9), and after 1–60 minutes (usually 1–7 minutes) ruptures in one or several places allowing the zoospores to escape (FIG. 9).

The resting spores of *C. spinosus* are usually ovoid in shape and contain a large refractive globule (FIG. 35). The wall varies conconsiderably in thickness, and in living material may sometimes appear to be slightly yellowish-green in color. These spores develop in the same manner as the zoosporangia (FIGS. 31, 32), and up to a certain stage it is impossible to distinguish between the two. However, by the time the incipient resting spores have reached definitive size, a large amount of refractive material is present in the cytoplasm which gives them a distinctive appearance (FIG. 33). As they mature, this material coalesces to form the large refractive globule shown in fig. 35.

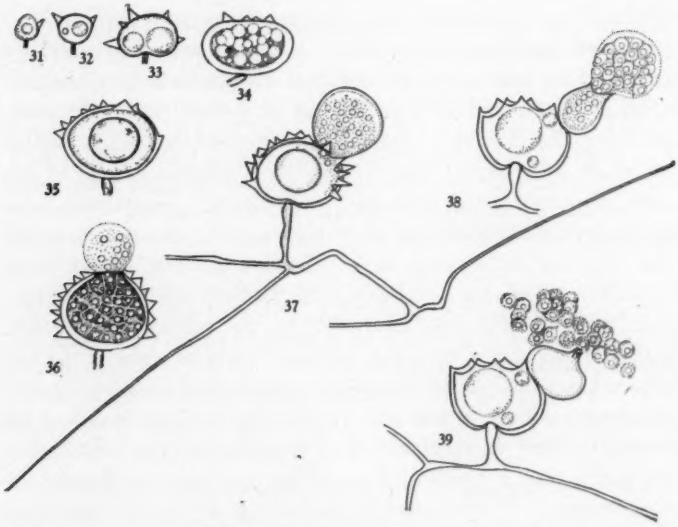

FIG. 2. *Chytriomyces spinosus.*

As in other species of *Chytriomyces,* the resting spores function as prosporangia during germination. As shown in fig. 36, the refractive material becomes more dispersed, a pore is formed in the wall and the protoplasm grows out as a small papilla. This enlarges into a sporangium which remains attached to the resting spore. This secondary sporangium varies considerably in size, but it is usually smaller than the primary sporangia described above.

SUMMARY

Chytriomyces spinosus occurs in nature chiefly on dead and disintegrating vegetation and may be readily cultured on bits of dried onion skin, leaves of grass, filter paper, and other substrata of this type. Unlike *C. aureus* and *C. hyalinus,* it is not markedly chitinophilic in its nutrient requirements. It differs structurally from these species by the presence of numerous abruptly-tapering spines on the surface of the sporangia and resting spores, and by slightly smaller zoospores. Its life cycle and type of development, however, are similar to those of *C. aureus* and *C. hyalinus.*

ACKNOWLEDGMENTS

The author wishes to express grateful thanks to Dr. John S. Karling for assistance in preparing the paper and to Dr. Edwin A. Quain, S. J., for the Latin translation.

EXPLANATION OF FIGURES

All drawings were made with the aid of a camera lucida. Spores enlarged freehand. All other enlargements by pantograph.

Chytriomyces spinosus. FIG. 1 (× 1630), regular arrangement of spines on sporangial surface; 2, 3 (× 480), maturing sporangium showing subapical slimy substance; 4 (× 560), mature thallus; 5, 6, 7, 9 (× 560), 8 (× 750), progressive stages in formation of the vesicle and emergence of the zoospores; 10–17 (× 800), curling and retraction of the flagellum, and germ-tube formation by zoospore; 18 (× 375), undischarged zoosporangium; 19–22 (× 800), *anlage* of rhizoids; 23 (× 800), 24 (× 1290), young papilla; 25 (× 1290), operculum; 23, and 26, 27 (× 560), refractile globules in young sporangium before dispersion; 30 (× 375), two undischarged zoospores developing within collapsed primary zoosporangium.

(Following figures all × 560): 31, 34, young stages of the developing resting spores; 35, mature ovoid resting spore with large refractive globule; 36, dispersion of the material in the mature resting spore followed by germination of the latter; 37, resting spore functioning as a prosporangium; 38, 39, germination of secondary sporangium.

THE EFFECT OF TEMPERATURE AND RELATIVE HUMIDITY ON THE LONGEVITY OF THE CONIDIA OF *HELMINTHOSPORIUM ORYZAE**

ROBERT M. PAGE, ARDEN F. SHERF AND THOMAS L. MORGAN

(WITH 1 FIGURE)

Brown spot of rice caused by *Helminthosporium oryzae* van Breda de Haan is a disease of importance wherever rice is grown. It causes most damage as a seedling blight, but may lower the yields of more mature stands to some extent by leaf lesions which reduce the effective photosynthetic areas of the leaves. On kernels, brown spot produces lesions which impair the milling quality of rice as well as the yield. Control of the disease consists mainly of seed treatments (Nisikado and Miyake, **1920**, Lin, **1936**) and field sanitation (Wei, **1936**).

Secondary spread of the disease is brought about by conidia which are banana-shaped, 5–9 celled reproductive bodies 80–130 μ long by 16–22 μ wide. *Helminthosporium oryzae* has been shown to possess extensive longevity in culture. Nisikado (**1922**) reported keeping it in culture for 943 days without transfer after which it resumed growth when fresh medium was added. Wei (**1936**) found that infested portions of rice plants could be stored on trees, on soil and underground for considerable periods without loss of viability by the fungus. In no case, however, has it been clear whether the vegetative mycelium or the conidia were responsible for the persistence, and the conditions of storage were not controlled.

Since *H. oryzae* produces large numbers of conidia on the leaves and heads of infected rice plants during favorable weather conditions, it was of interest to learn something of the longevity of the conidia under various environmental conditions. Therefore ex-

* Results of investigations conducted at Camp Detrick from May, 1944 to December, 1944.

periments of two types were conducted to determine first, the effect of temperature, and second, the effect of both temperature and relative humidity combined on the longevity of the conidia.

EFFECT OF TEMPERATURE

The conidia used in the experiments were produced by growing *H. oryzae* on moistened sterilized oats. Three hundred grams of oats in Fernbach flasks were moistened with 345 ml. of water, steamed for 30 minutes and autoclaved at 15 lbs. pressure for 20 minutes. The flasks were then allowed to stand over night and reautoclaved. After the flasks cooled, they were inoculated with an aqueous suspension of conidia and incubated for 14 days at 22–24° C. in the dark. The conidia were left in contact with the substratum, and the contents of the flasks were dried in a steam oven for 24 hours at 40° C. One to two grams of infested oats were placed in small vials closed with screw caps. The vials were stored at various temperatures and the viability of the conidia determined periodically.

The viability of the conidia was measured by making germination counts. The conidia were removed from the containers with a sterile loop and placed in a drop of sterile water on the surface of potato-dextrose agar in a Petri dish. The suspension was streaked

TABLE 1

VIABILITY (*expressed as per cent germination*) OF CONIDIA OF HELMINTHOSPORIUM ORYZAE STORED AT VARIOUS TEMPERATURES

Length of Storage (Days)	Temperature (° C.)					
	2°	10°	21°	RT*	27°	31°
7	91	90	93	92	93	91
15	89	74	78	83	82	89
22	91	88	85	85	90	89
28	89	81	80	81	87	73
40	90	85	80	76	73	63
48	92	85	67	67	74	29
60	93	79	60	69	57	19
70	93	82	56	73	63	30
81	87	85	45	71	73	26
90	97	85	47	74	81	15
100	81	66	17	56	42	6

* Room temperature approximately 24° C.

over the surface of the agar and the conidia allowed to germinate for four hours. A total of approximately 200 conidia, germinating and ungerminated, was then counted with the 16 mm. objective and the percentage of germinating conidia calculated. The results (TABLE 1) indicated that the conidia retained their viability best when stored at low temperatures. At the end of the experiment, after 100 days storage, 81 per cent of the conidia stored at 2° C. were viable, whereas only 6 per cent of those stored at 31° C. were capable of germinating. Although there was some irregularity and inconsistency in the results, the trends were clear. Some of these irregularities may have been due to the differences in relative humidity of the various places of storage, since the screw caps on the vials did not completely prevent air exchange.

EFFECT OF TEMPERATURE AND RELATIVE HUMIDITY

The method of producing conidia to test the effect of temperature and relative humidity combined was the same as that described in the preceding section. The conidia were removed from the substratum by several successive portions of water which were added to the flasks and then shaken vigorously. The resulting suspension was strained through wire gauze to remove the seeds, poured into cylinders and allowed to settle over night at 8° C., a temperature sufficiently low to preclude germination of the conidia during the settling process. After the supernatant liquid was decanted, the conidia were collected on coarse filter paper in a Buchner funnel. The filter cake was broken up and dried at 40° C. for 24 hours.

For the experiments in which the relative humidity was controlled, small samples (of the order of 20 mg.) of conidia were placed in 15 × 150 mm. test tubes which had been cut to a length of approximately 90 mm. Each test tube was placed in a half pint milk bottle which was closed with a waxed cardboard disk. The relative humidity within the bottles was regulated with sulfuric acid solutions (Stevens, **1916**). The acid solutions were adjusted to provide the correct vapor pressure at 25° C., and were not corrected for differences in storage temperatures, since the temperatures used would change the relative humidity less than two per

cent from the desired value. In this experiment the conidia were stored over acid solutions which provided four relative humidities: 20%, 45%, 70% and 95%. Temperatures were controlled by placing the containers in constant temperature rooms which were thermostatically regulated within two degrees centigrade of the desired temperature. Germination counts were made periodically as described previously.

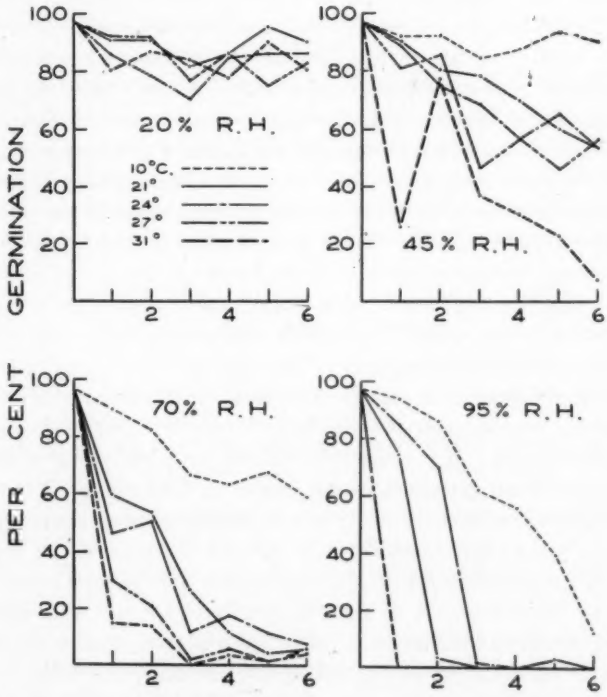

FIG. 1. Graph showing the viability of conidia of *Helminthosporium oryzae* stored at relative humidities of 20, 45, 70 and 95 per cent at various temperatures.

The results (FIG. 1) showed that the relative humidity during storage was a more important factor influencing longevity than temperature alone. For example, at 20 per cent relative humidity

the conidia survived for six months with little loss of viability even at 31° C., whereas at 95 per cent relative humidity they failed to germinate after one month at 31° C. Viability was retained best at low temperatures at all relative humidities.

DISCUSSION

The results obtained agreed in general with those of Peltier (**1925**) who found that with the urediospores of *Puccinia graminis tritici* the lower the temperature the longer the spores retained their viability at all relative humidities. A similar relationship was found with the flag smut of wheat, *Urocystis tritici* Koern., the spores of which remained viable longest at low relative humidities. Noble (**1934**) found that the spores of this fungus would retain their viability for at least ten years when stored at relative humidities below 33.5 per cent at uncontrolled temperatures which ranged from 13 to 31° C. The results obtained with *H. oryzae* were in contrast to those obtained with the conidia of the downy mildew of tobacco which remained viable longest (two months) under cool, moist conditions (3°–5° C., 60–80% relative humidity) according to Angell and Hill (**1931**).

The importance of relative humidity as a factor influencing longevity may be connected with the influence of moisture on conidial germination. Numerous investigators have reported that fungus spores will germinate in the absence of free water. Katsura (**1937**) claimed that the conidia of *Helminthosporium oryzae* germinate at a relative humidity of 92 per cent but not at 89 per cent. In the present investigation, no germinating conidia were observed among those stored at 95 per cent relative humidity. At such a high humidity, however, the conidia must have approached germination. It would seem possible that some metabolic activities could progress under such conditions, and that the failure of the conidia to germinate after storage at high relative humidity may have been due to exhaustion of stored food reserves.

From these laboratory studies, it would appear that the conidia of *H. oryzae* are not likely to maintain their viability for long periods in the field. The warm, moist climates of many rice growing regions would be most unfavorable for the survival of conidia.

Since they failed to germinate after one month's storage at 95 per cent relative humidity at 31° C., and survived only three months at 24° C., it would be most unlikely that the conidia could survive through the winter under field conditions. The primary function of the conidia, then, would seem to be connected with the spread of the fungus rather than with its persistence.

SUMMARY

1. Low temperatures favored the retention of viability by the conidia of *Helminthosporium oryzae*.

2. In controlled temperature experiments in which the relative humidities during storage were controlled with sulfuric acid solutions, the conidia remained viable longer under cool dry conditions. At 20% relative humidity the conidia survived for six months with little loss of viability even when stored at 31° C., whereas at 95% relative humidity they failed to germinate after one month at 31° C.

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YEASTS IN DECOMPOSING FLESHY FUNGI

K. W. Anderson and C. E. Skinner

It has frequently been noted that yeasts are present in decomposing mushrooms but little knowledge of the identity of the yeasts is available. The present study is an attempt to supply information on this question.

Each species of mushroom (or other fungus) was placed immediately in a clean glass jar with a loose fitting screw-top cover as soon as it was gathered in the field. All of these were brought to the laboratory and unless the diagnosis of the fungi could be made in the field, duplicate samples were collected for later identification. Diagnoses were checked by the late Dr. A. T. Henrici. The jars were stored at laboratory temperature (about 25°–30° C.) and in two or three days, rarely longer, liquefaction had commenced. Tests for pH were made by the glass electrode at two or three day intervals. If an alcoholic fermentation became evident by an alcoholic or an esteric odor, attempts were made to isolate yeasts when such fermentation was most active. In case there was no such odor, attempts were made to isolate yeasts after liquefaction had proceeded two or three days. Glucose-tartaric acid-beef-peptone agar (3) was used for isolation. In cases where yeasts were not isolated, the fluid from the liquefied fungus was examined microscopically to verify the absence of yeast cells.

After the purity of the cultures was established, the yeasts were studied by the various biochemical and morphological methods outlined by Stelling-Dekker (4) and Lodder (2) in their monographs on sporogenous and asporogenous yeasts respectively. These same two works were also consulted to identify the yeasts. In most cases the identification was certain, but in a few cases there was a slight difference, usually in availability of nitrates or of rate of gelatin liquefaction. The differences were not in most cases such as to make us consider the possibility that we had new species. There was one *Saccharomyces* and one *Cryptococcus* that could not be placed in any species known to us, and isolations,

apparently representing several species, from eight fungi that could not even be placed in a genus. It was finally decided that these were probably sporidia of smuts. Cultures were submitted to Dr. J. J. Christensen, who also thought that they were sporidia of smuts but he was unable to identify any of them.

The following table shows the kinds of yeasts isolated, the fungi from which they were obtained, the pH at the beginning of liquefaction, and the number of strains studied.

OCCURRENCE OF YEASTS IN DECOMPOSING FLESHY FUNGI

Yeast	Fungus in which Yeast was Found	pH Beginning of Liquefaction	Number of Isolations
Saccharomyces cerevisiae Hansen (various varieties)	*Agaricus campestris*	8.2	2
	Armillaria mellea	3.6	1
	Coprinus micaceus	4.6, 4.41	9
	Coprinus ebulbosus	4.9, 4.7	6
	Coprinus comatus	6.0	1
	Hypholoma appendiculatum	4.41	6
	Lepiota Morgani	6.0	6
	Marasmius oreades	4.83	5
	Peziza odorata		2
	Phallus impudicus	3.7	1
	Russula emetica	4.5	6
Saccharomyces Chodati Steiner	*Lepiota naucina*	6.5	4
Saccharomyces dairensis Naganishi	*Armillaria mellea*	3.6	3
	Coprinus ebulbosus	4.9, 4.7	5
	Panus rudis	4.1	6
	Pluteus cervinus	5.21	6
Saccharomyces disporus Beijerinck	*Coprinus comatus*	6.0	1
	Coprinus micaceus		1
Saccharomyces heterogenicus Osterwalder	*Pholiota praecox*	5.21	4
Saccharomyces muciparis Beijerinck	*Peziza odorata*	7.0	4
	Tremella mesenterica	4.6	5
Saccharomyces sp.	*Mycena pura*	4.9	6
Cryptococcus pulcherrimus (Lindner) Benham	*Strobilomyces strobilaceus*	5.4	5
Cryptococcus utilis (Hennenburg) Anderson et Skinner*	*Strobilomyces strobilaceus*	5.4	1
Cryptococcus uvae Pollacci et Nannazzi	*Agaricus campestris*	8.2	1
	Coprinus micaceus	4.6	4

* **Cryptococcus utilis** (Hennenburg) Anderson et Skinner, comb. nov. Syn.; *Torula utilis* Hennenburg; *Torulopsis utilis* Lodder.

OCCURRENCE OF YEASTS IN DECOMPOSING FLESHY FUNGI—*Continued*

Yeast	Fungus in which Yeast was Found	pH Beginning of Liquefaction	Number of Isolations
Cryptococcus sp. Except for the fact that no red color appeared, this is very like *Torulopsis pulcherrima* (Lindner) Sacc. var. *variabilis* Lodder	*Amanita muscaria*	4.54	7
	Armillaria mellea	3.6	1
	Coprinus micaceus	4.6	4
	Marasmius oreades	4.83	1
	Phallus impudicus	3.7	4
Rhodotorula colosteri (Castelli) Lodder	*Clavaria stricta*		5
	Pholiota praecox	5.21	1
Group 20—sporidia?	*Agaricus campestris*	8.2	2
	Amanita muscaria	4.7	6
	Amanita verna	7.8	4
	Boletus chrysenteron	6.85, 6.87	11
	Coprinus comatus	6.0	4
	Coprinus ebulbosus	4.7	8
	Coprinus micaceus	4.6	4
	Inocybe rimosa	6.3	6
Yeasts present, but not isolated	*Coprinus micaceus*	6.65	
	Tricholoma albellum	7.66	
	Boletus Satanas	5.15	
Not isolated and not seen in microscopic examination	*Coprinus atramentarius*	8.39	
	Agaricus arvensis	8.29	
	Calvatia gigantea	8.9	
	Polyporus betulinus	4.61	
	Marasmius oreades	8.6	
	Collybia radicata	7.62	
	Lycoperdon subincarnatum	8.24	
	Hypholoma incertum	7.95	
	Lycoperdon pyriforme	7.95	
	Daedalea confragosa	5.2	
	Calvatia cyathiformis	6.95	
	Russula alutacea	6.65	
	Amanitopsis vaginata	6.25	
	Lepiota Morgani	8.05	
	Clavaria aurea	6.3	
	Clavaria cristata	5.8	

There are several points in the table that might be commented on. The fact that such a large number of yeasts were isolated very readily from decomposing mushrooms indicates that we have in mushrooms an important habitat for these organisms which are probably carried thither by insects, many of which are known to harbor large numbers of yeasts. The chemical composition of several species of mushrooms has been determined (**1**, **5**, **6**). Many species have smaller or larger amounts of fermentable or

utilizable monosaccharides. Considerable amounts of trehalose are also found in many mushrooms. Most yeasts are entirely unable to utilize or ferment trehalose. The hydrolysis to glucose must first be brought about by enzymes of the fungus itself, or of bacteria which are present with the yeasts. The presence of these carbohydrates thus makes the fleshy fungi a good medium for yeasts.

Secondly, it should be noted that a large percentage of the yeasts found formed ascospores. An unexpectedly small number of imperfect yeasts all belonging to the genus *Cryptococcus* or *Rhodotorula* were found, and none that could be identified as species of the common genus *Mycoderma*.

Another point of interest is the obvious connection between the presence of yeasts and low initial pH. pH determinations were made as soon as the fungi had liquefied sufficiently to obtain samples. In most cases low initial pH, an odor of alcohol or esters, and presence of yeasts went together. In nearly all cases where yeasts were not found, the odor was ammoniacal and the pH was high. It is probably not primarily the yeasts which make the medium acid since they are usually not strong acid producers; rather the yeasts became established in media made sufficiently acid by bacteria to prevent putrefactive bacteria from proliferating rapidly. This is a problem in pure ecology that should be worked out.

To verify the findings that yeasts usually are numerous only in decomposing mushrooms of high acidity the following additional work was done: Several samples of species of *Coprinus* were collected and allowed to decompose as described above. After liquefaction was well started pH determinations by colorimetric methods were made and yeasts were searched for by microscopic examination. Samples with the following pH yielded yeasts: pH 3.8, 4.0, 4.1, 4.3, 4.3, 4.6, 4.6, 4.6, 5.3, 5.6, 5.8, 6.0, 6.5, 7.6, 7.9, 8.1. The following failed to show yeasts: pH 6.8, 7.8, 8.2, 8.6, 8.9, 8.9. All except four of those with yeasts had a definite alcoholic or esteric odor, and all but one of those without yeasts had an ammoniacal odor. Thus the results of the former more carefully controlled experiments were confirmed: Yeasts will be expected to be found only in those samples of decomposing mushrooms which are acid.

Yeasts were isolated from only some of these samples, but from all in which an attempt was made to isolate them. The collection of perfect yeasts was lost, but the following additional imperfect species were identified: *Rhodotorula glutinis* (Fres.) Harrison, *Cryptococcus californicus* (Mrak et McClung) Anderson et Skinner [1] and *Cryptococcus spaericus* (Hammer et Cordes) Anderson et Skinner.[2]

SUMMARY

Yeasts were isolated from decomposing fungi, largely mushrooms, but also from some fleshy Ascomycetes. Samples of high pH rarely yielded yeasts, but those of low pH usually did so. The following yeasts were identified: *Saccharomyces cerevisiae, S. Chodati, S. dairensis, S. disporus, S. heterogenicus, S. muciparis, Cryptococcus californicus, C. pulcherrimus, C. spaericus, C. utilis, C. uvae, Rhodotorula colosteri, R. glutinis.*

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2. **Lodder, J.** 1934. Die anaskosporogenen Hefen. 1st Hälfte. Verh. Kon. Akad. Wetensch. Amsterdam Afd. Natuurk. 2 Sect. **32**: 1–256.

[1] In order to retain the specific name *californicus* and to prevent the creation of another which would have to be considered valid, the following description is given with Dr. Mrak's approval:

Torulopsis californica Mrak et McClung: Cellulae sunt globosae in culturis maltatis liquidis, juvenes (usque ad 24 horas) 3.5–5.75 × 4.5–6.0 μ, seniores (3 diebus) 5.25–7.0 × 5.25–8.75 μ. Ascosporae non visae sunt. Dextrosum, laevulosum, mannosum, galactosum, maltosum, succrosumque fermentantur, neque autem lactosum nec raffinosum. Asparagin, sulfas ammoniae, urea, peptonumque leniter absorberi possunt, neque autem nitrates. Auctus est bonus in mediis in quibus spiritus frumenti fons carbonis solus est. Gelatinum non liquefitur. Habitat in culturis ex baccis *Vitis viniferae*, California. Descriptio extensior (*Torulopsis californicus*) lingua anglica facta est in *Jour. Bact.* **40**: 401, 1940. **Cryptococcus californicus** (Mrak et McClung) Anderson et Skinner, comb. nov. Syn. *Torulopsis californica* Mrak et McClung.

[2] **Cryptococcus spaericus** (Hammer et Cordes) Anderson et Skinner, comb. nov. Syn.: *Torula spaerica* Hammer et Cordes; *Torulopsis spaerica* Lodder.

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TYPE STUDIES ON BASIDIOMYCETES III *

ROLF SINGER

Most of the types reported on here are deposited in the Farlow Herbarium (FH), Harvard University. A few species were studied at the New York State Museum, Albany (NYS), or in the Herbarium of the Agricultural Experiment Station, University of Florida (FLAS).

FAM. RUSSULACEAE

LACTARIA TORMINOSA VAR. GLABRA Murr., Lloydia **6**: 209. 1943. (Type.) LACTARIUS PSAMMICOLA A. H. Smith, Papers Mich. Acad. Sc., Arts, Letters **26**: 62, pl. 1. 1941. (Type.)

Murrill says that *L. torminosus* "is exceedingly abundant" in Gainesville, and also describes the above-cited var. *glabra* of that species. We have carefully studied the type of this variety as well as the specimens determined as *L. torminosa* in the Gainesville Herbarium, and our conclusion is that none of them belongs to *L. torminosus*. This incorrect determination of the plant in question is not directly Murrill's fault. Murrill, in order to determine his *Lactarii* of Florida, relied on Coker's monograph of the species of South Carolina where the same species is likewise described under the name of *L. torminosus*. Actually, the species occurring so abundantly in the south, and much less commonly in the north of the United States, and corresponding to the characters indicated by Coker, had no valid name up to 1941. A. H. Smith seems to be the only one who clearly saw this situation, and, as a consequence, described this fungus as a new species, *L. psammicola*, the type of which I have seen at Ann Arbor, in 1941. Though it has been well described by its author (*l.c.*), our own description is based on innumerable collections and adds some chemical and anatomical data not given before:

* Cf. Singer, R. Type studies on Basidiomycetes I–II. Mycologia **34**: 64, 1942; **35**: 134, 1943.

Pileus in early youth with "ochraceous orange" zones on "ochraceous buff" ground, later paler, *i.e.*, the zones "ochraceous buff," "cinnamon buff," "pinkish buff," "clay color" on a "pale pinkish buff" or "pale ochraceous buff" background, viscid, glutinous in the central half, slightly viscid in the marginal half, appressed tomentose or merely cobwebby-fibrillose or loosely woolly in the marginal half or third, increasingly so toward the very margin but in some individual fruitbodies sooner, in others later glabrescent from the middle outwards depending on habitat and weather, often with irregular ridges above the gills formed by the tomentum, with acute, involute margin that becomes straight in age, initially convex and deeply umbilicate, then the marginal quarter of the radius convex, the central part deeply infundibuliform, eventually often wholly concave, (55)100–185 mm. broad. *Lamellae* "cartridge buff," staining "fawn color" where they had been in prolonged contact with the droplets of the latex, subclose to crowded, forked, often forked-connate at the stipe, linear, narrow (3–7 mm. broad), arcuate-decurrent, or adnate-subdecurrent; spore print F (Crawshay's plate). *Stipe* white or whitish, the apex often with a more or less distinct "yellowish glaucous" band, in early youth in some specimens distinctly scrobiculate with spots concolorous with the pileus but later rarely and then sparsely scrobiculate, usually becoming smooth and unicolorous, the apex usually with a 2 mm. broad zone of longitudinal ridges continuing the lamellae, not discolored when handled, glabrous, firm, tapering downwards, (12)30–40 × 17–33 mm., considerably thinner below. *Context* pallid or concolorous with the surface though paler, rather firm but not rigid in the pileus and rather thick (5–9 mm.) there, slowly changing to "pale vinaceous fawn" and "pale Quaker drab," reaching "lavender gray" in the marginal third, the discoloration sometimes very indistinct and remaining unobserved if special attention is not paid to the color of the wounds after a time of 10 minutes from the moment of the bruising; latex not pure white, between "cartridge buff" and white, unchanging or concolorous with the injured portions of the tissue when left in contact with the latter for a prolonged time; odor agreeable, of apple; taste rather strongly acrid in a few seconds.

Spores 7.3–10(11.5) × (6)6.3–8(9.2) μ, asymmetrical, short-ellipsoid, hyaline, yellowish-hyaline in accumulations, coarsely warty on periphery, in iodine with long ridges (ornamentation of type I, more rarely II, never III) which project 0.9–1.3 μ and react strongly amyloid; *basidia* 40 × 9.5 μ, 4-spored; *pseudocystidia* 48–52 × 4–8 μ, fusoid, mostly with faintly banded contents but some always empty, with the bases proliferating to the trama, somewhat undulate-sinuose at times, attenuate upwards and subacute

or narrowly obtuse; trama filamentous with many thin, (2.5–3 μ broad) laticiferous vessels; all hyphae without clamp connections; context with large laticiferous vessels running in all directions, hyaline; subcutis the same as the context but colored succineous-melleous and the hyphae (not the laticiferous vessels) running mostly parallel and horizontal; epicutis the same as the subcutis but less pigmented, the hyphae looser because of the gelatinous nature of the layer, the more scattered laticiferous vessels running parallel with the hyphae, and thinner than in the context; all laticiferous vessels bluing in sulphovanilline; dermatopseudocystidia none.

Methylparamidophenol strongly positive, reaching a deep lilac; **phenol,** strongly positive to "dusky brown" with "russet vinaceous" margins; **$FeSO_4$,** sordid; **H_2SO_4** and sulphovanilline, reddish black; **KOH,** weak reaction to slightly yellowish, the latex negative; **HCl, NH_3** and **NH_4OH,** negative or almost negative; **aniline** with lamellae somewhat slate gray after a while (vapors); context slowly salmon color then chocolate, then black (any of these phases may be wanting at times; use aniline oil).

Under oaks in high hammocks, in scrub areas, and on shaded lawns, generally on sandy soil in wooded areas with *Quercus,* gregarious, fruiting from May till October. From New England and the Middle West south to the Gulf of Mexico becoming more common southwards (same distribution as in *Russula albida* Peck, see below). Var. *glabra* Murr. is a form without taxonomic importance; the valid name for it, as well as for Coker's and Murrill's (Florida) *L. torminosus,* is *L. psammicola* A. H. Smith. The ornamentation of the spores and the chemical characters of the true *L. torminosus* of Europe and the northern states and Canada, are quite different.

RUSSULA DELICA Fr. sensu Bresadola, Fungi Trid. **2**: 88, pl. 201. 1900; Icon. **9**, pl. 401. 1929. (Authentic material.) RUSSULA DELICA var. BRESADOLAE Sing., Bull. Soc. Myc. France **54**: 132. 1938. (Type.) RUSSULA BREVIPES Peck, Ann. Rep. N. Y. State Mus. **54**: 178. 1901. (Type and authentic material.)

The variety *Bresadolae* Sing. is based on the author's collections which were identified with *Russula delica* Fr. sensu Bresadola. J. Schäffer indicates that the latter is *R. pseudodelica* Lange. I have carefully compared the latter with my own specimens, and find the spores decidedly different. Schäffer's statement sounds

puzzling if one examines a specimen collected and determined by Bresadola as *Russula delica* Fr. (September 1926, at Trento in oak woods), and distributed by J. Schäffer himself, with spores ornamented 1.5 μ high and more (*i.e.*, typical *delica*-spores), and the appearance and characters of the specimens exactly like those of *R. delica* var. *Bresadolae*.

We have also studied Peck's type of *R. brevipes* and material freshly collected at places where Peck's material of *R. brevipes* had been found. We could not discover any macro- or microscopical, or chemical difference between this and the European *R. delica* Fr. var. *glaucophylla* Quél. This coincides with the almost unanimous treatment this species has found in monographs. The writer finds the fresh spore print of most American collections either B, or between B and C (Crawshay).

RUSSULA SUBALBIDULA Murr., Mycologia **33**: 441. 1941. (Type.)

The type of *R. anomala* Peck was reported on in a previous paper (Mycologia **35**: 145. 1943), and recent collections in the northern part of the United States have shown that this species is not always as small as described by Peck, but also occurs in a medium sized form not otherwise distinguishable from the small type form. The type of *Russula subalbidula* is not distinguishable from this medium sized form of *R. anomala* Peck, except perhaps by being usually slightly less acrid. Since the writer has studied hundreds of fresh specimens of this species,[1] a complete description can now be given:

Pileus white or dull white with the disk frequently tinged pale buff to pale cream color, glabrous or sometimes slightly pruinate on the margin, unpolished, very slightly gelatinized during rainy weather, margin smooth, only in age short and irregularly sulcate, the margin forming an angle of about 90° (subacute) or obtuse from the beginning, always obtuse in age though not truly rounded, surface convex, the center soon broadly but usually not deeply depressed, the cuticle separable one sixth to one fourth of the radius from the margin, diameter 40–100 mm., rarely as small as 25 mm. *Lamellae* white, then cream color, close to subclose, attenuate-attingent to subdecurrent, eventually irregularly attached, not ventricose, rather narrow, more rarely rather broad, in average specimens 4–9 mm. broad, equal and simple, or if growth has been held back partially because of mechanical obstacles, a few shorter

[1] These are being distributed in Reliquiae Farlowianae, no. 992.

and forked ones are intermixed, low anastomoses present; spore print B (Crawshay), near " ivory yellow" (Ridgway), more yellow but not deeper colored than in Crawshay. *Stipe* white, initially subpruinose, glabrescent, slightly longitudinally rugulose, solid, then stuffed or hollow, slightly tapering upwards or downwards or subequal, 26–50 × (6)14–28(45) mm. *Context* white, unchanging, firm, eventually rather fragile; odor none or very slight of coconut; taste very slightly bitterish and acrid at the same time, the burning sensation of variable intensity, intensely acrid when young and fresh in some specimens but usually moderately, and eventually becoming subacrid to mild in old ones.

Spores 10–10.5 × 8.5–8.8 μ when taken from a print, hyaline, echinate, ornamentation rather variable (most frequently of type VI, V, IV, also IIIb, rarely a few spores with type IIIa, or IV–II), 0.6–1.2 μ high, with the spines regularly or irregularly arranged, dense to sparse, mostly cylindric but also conic-obtuse; *pseudocystidia* 70 × 14–17 μ, some narrower, some shorter, but in an average rather voluminous, at least in the strongly acrid forms, clavate to fusoid, mostly bluntly rounded at apex, numerous, with banded contents, strongly and entirely bluing in sulphovanilline; basidia 37 × 6.5–7.5 μ, 4-spored; *epicutis* with numerous dermatopseudocystidia on the pileus and on the stipe (blue in sulphovanilline).

$FeSO_4$, somewhat inconstantly reacting, mostly grayish green on cuticle ("Andover green," "Lincoln green," "slate olive"), in one specimen merely grayish pallid; on lamellae pale grayish green or negative, never salmon colored anywhere. **Phenol,** chocolate (normal). **Formalin,** "light grayish vinaceous" to "vinaceous fawn" in 3–5 min. **Sulphoformol,** bright blue: "neropalin blue." **Sulphovanilline,** blue on fresh context. **Chloroformol** (40 per cent formaldehyde with concentrated HCl added), slowly bluish gray. **Nitroformol** (with concentrated HNO_3 added), somewhat blue after 6 minutes. **HNO_3**, dirty isabelline, eventually yellow on surface of pileus. **HCl** and **H_2SO_4** on pileus, negative. **Methylparamidophenol,** rather strongly positive. **Aniline** on lamellae slightly dull red with a pale melleous margin, almost negative.

In mixed and oak woods, high hammocks and on shaded lawns under oaks, solitary to very gregarious; fruiting from May until July, probably also later. Eastern United States.

Material studied: **N.Y.** Type of *R. anomala* (NYS). **Fla.** In and around Gainesville, Alachua Co., common in early summer, *R. Singer,* F1971a, F1971b (FH). Type of *R. subalbidula* Murr.

(FLAS); also authentic material (FLAS) and fresh material of the writer authenticated by Murrill (FH). **Mich.** Waterloo, singly under oak and juniper, July 20, 1942, *W. B. Gruber* (A. H. Smith 18520), det. R. Singer (MICH, FH). **Ala.** Alabama Biological Survey, Dadeville, Aug. 28, 1897, *C. F. Baker* (Burt Herb., FH); other collections from Alabama (*Earle*) in the herbaria (NY, NYS) are not, as they were determined, *R. albella,* but *R. anomala* (*R. subalbidula*).

Earle determined and published his Alabama specimens under the name *albella* before Peck had published the Long Island collection of *R. albella,* but they are different. Since Earle's *R. albella* is a *nomen nudum,* we recognize Peck's type at Albany as valid. This has occasional red hues, reticulate spores and more scattered dermatocystidia, and may possibly be an albino form of some normally reddish species of the section Rigidae.

R. anomala belongs in the section *Ingratae,* subsection *Felleinae.* It is related to *R. fellea* Fr. (*R. simillima* Peck [2]), *R. innocua* Sing. (*R. albida* Peck sensu Kauffm. p.p. *non Peck sensu originali*), etc. It is remarkable for its reactions. Specimens preserved in the preserving fluid "vasco" also become blue as has been pointed out by Murrill. The blue reaction with sulphoformol was previously known only from one European species, *R. rosea* Quél. (*R. aurora* Krombh. *sensu* Melzer & Zvára *non* Bres.) sensu R. Maire (1910) *non* Singer (1926), and its smaller variety, *R. rosea* var. **minutula** (Velen.) Sing. comb. nov. = *R. minutula* Velen. = *R. uncialis* Peck *sensu* Melzer & Zvára *non sensu originali.* In this species, the sulphoformol reaction is accompanied by a parallel bright red sulphovanilline reaction whereas, in *R. anomala,* the sulphovanilline reaction is not bright red. *R. anomala* is not related to *R. rosea.*

Considering the fact that the northern *R. anomala* was very little known and its macroscopical description not fully suggestive of the medium sized moderately acrid form commonly found in Florida, it is understandable that Murrill redescribed it under a new name. This latter—though better supported by a recognizable description and a larger number of specimens than Peck's

[2] *R. simillima,* as collected fresh in the Adirondacks, N. Y., is only a form or race of *R. fellea* Fr.

species—must nevertheless be considered as a synonym of *R. anomala* Peck.

RUSSULA MACULOSA Murr., Lloydia **6**: 212. 1943 (Type and fresh material from type locality, compared with the type).

Pileus white with sordid or rusty brownish spots or patches, or a very pale Isabella color (not in Ridgway) on the cracked surface, usually center and patches "chamois," otherwise pallid white, opaque, dry or slightly viscid, with acute or subacute margin which becomes more obtuse in age but never rounded, smooth then usually short to long sulcate or striate, surface convex then flattened and depressed, sometimes umbilicate, eventually concave, initially with broadly incurved margin, diameter 40–105 mm. *Lamellae* white, becoming pale cream color, unchanging or slightly staining brownish where injured, crowded to subclose, plane, equal or with very short lamellulae on the margin, some or usually many forked, especially near the stipe (bifurcate-connate), narrow, with entire edge, not or scarcely anastomosing, narrowly adnexed to subdecurrent, sometimes somewhat separating from the apex of the stipe; spore print from between A and B to B (Crawshay). *Stipe* white, at times with rusty or alutaceous spots, or slowly becoming so when injured, glabrous or subglabrous, solid, later stuffed, slightly tapering downwards or upwards, or ventricose, or more rarely subequal, 30–60 × 10–30 mm. *Context* white, rarely slightly pale brownish alutaceous after long exposure, usually unchanging, thin to medium thick but firm-elastic in the pileus; odor none, or eventually (often on drying) becoming disagreeable, of sweat (as in *R. parazurea*), or chloride of lime (as in certain Amanitas); taste mild in all stages.

Spores (5.8)6.5–8.7 × (4.2)5.3–7 μ, mostly 7.5–8.2 × 6.2–6.5 μ, short-ellipsoid to subglobose, slightly rough, ornamentation (0.1) 0.2–(0.5) μ high, of type (IIIa), IIIb, IV, V, (VI), IIIb–VIII, IIIb–VII, with one small round oil droplet; *basidia* 27–54 × 8–10.5 μ, mostly 38–44 × 8.7–9.2 μ, clavate, 4-spored; pseudocystidia 37–75 × 6.2–11.5 μ, most frequently 65–75 × 7.2–11 μ, cylindric or fusoid, rarely capitate, sometimes fusoid-clavate, not appendiculate, or rarely some short appendages present, usually moderately numerous, a majority with at least an apical internal body bluing in sulphovanilline, many with banded contents in some part, few with evenly scattered contents obtuse or subacute, sometimes with a subcylindric bottle-neck apex; *cheilocystidia* not differentiated; edge homomorphous; *subhymenium* a rather thin subcellular layer; *trama* with large and numerous spherocysts and large filamentous areas; *surface of stipe* with subfasciculate hyphal ends cylindric-

capitate, 3.5–4.3 μ in diameter; *epicutis* of pileus consisting of cellular chains (cells 10–18 × 7–15 μ), sometimes the upper members becoming increasingly narrowed as they approach the tip of the chain, the terminal member usually hair-like, often bottle shaped, occasionally clavate (*e.g.* 22 × 9 μ), or cylindric (20 × 4.5 μ); there are also some hyphal ends reaching the epicutis, and some of them are incrusted (primordial hyphae); *subcutis* made up of somewhat interwoven, repent hyphae which are long-filamentous, 2.5–4.5 μ in diameter, hyaline, smooth, and clampless.

$FeSO_4$, everywhere constantly salmon color. **Methylparamidophenol,** strongly positive. **Sulphovanilline,** on dried surface of stipe "garnet brown" (deep red). **Chlorovanilline,** negative everywhere.

Under frondose trees, mostly oaks, preferably *Quercus virginiana* and *Q. laurifolia* in Florida, on the ground, solitary or gregarious; fruiting from May until October. From the Carolinas south to North Florida and west to Tennessee and Alabama.

The above is an emended description of the plant called *R. chlorinosma* Burl. in Bull. Soc. Myc. Fr. **55**: 242. 1939, and at the same time of *R. maculosa* Murr. The latter is a synonym of the former unless—quite unexpectedly—the type of *R. chlorinosma* should turn out to be specifically different from the form described above.

This species is easily distinguished from *R. crustosa* Peck (the closest relative), by the color if observed unbleached in both cases, also by the slightly acrid taste of *R. crustosa* when young. We have observed another species in Florida that belongs in the same stirps. It closely resembles *R. chlorinosma* (*R. maculosa*) but has more narrowly ellipsoid spores. This shape is not within the limits of variation of *R. chlorinosma,* but rather reminds one of that of *R. heterospora* Beardslee. It is remarkable that the North and Central Floridan agaric flora is so rich in narrow spored species in groups where short spored species are the rule, and this not only in *Russula* but also in *Amanita,* and most striking, in *Hygrophorus* (such as *H. russuliformis, H. subsordidus* Murr.).

RUSSULA ALBIDULIFORMIS Murr., Lloydia **6**: 209. 1943. (Type.)

Pileus white to whitish, more moist than viscid when wet, glabrous, convex, then more or less depressed, fleshy, with incurved,

then acute, smooth, but eventually striate margin, with a cuticle that scarcely peels for any distance from the margin, diameter 60–80 mm. *Lamellae* white, then pale orange, adnexed, often separating from the stipe, comparatively thick, many forked, especially near the stipe, or at half-height, equal, close to subclose, moderately broad; spore print somewhat more salmon colored than B of Crawshay's plate ("pale pinkish cinnamon"). *Stipe* white, smooth, solid or somewhat stuffed, usually subequal, 50 × 12–16 mm. *Context* white, unchanging, rather hard; taste mild; odor none, eventually agreeable like that of apples.

Spores 7–9.8 × 5–6.5 μ, slightly rough to subsmooth, hyaline, ornamentation up to 0.2 μ high, of type VII, or VI, V, IV, III, mostly consisting of crossing lines forming small warts at the nodes, about as figured for *R. melliolens* by R. Maire (1910); *basidia* 37–48 × 8.8–11.2 μ, 4-spored, either the short or the elongated type prevalent; *cystidia* 53–75 × 5–10.2 μ, wavy, fusoid, or subulate, or ampullaceous, rather characteristic in appearance, sometimes with 1–3 basal septa (the lower divisions not a part of the subhymenium), inside empty in all parts, or finely granulose partly or entirely, without, however, any banded contents; *cheilocystidia* none; edge homomorphous; *subhymenium* consisting of small cells, not filamentous at all; *trama* of large spherocysts, with many connective hyphae intermixed among them; *epicutis* made up of hair-like dermatocystidia (not of the pseudocystidia-type), these are subulate and do not turn blue in sulphovanilline, empty or with the same kind of contents as observed in the hymenial cystidia, hyaline, very crowded; all hyphae without clamp connections.

$FeSO_4$, negative. **Formalin,** negative.

Under and near oaks in high oak woods and in the scrub (not in very dense hammocks), on sandy soil, solitary or in small groups; rare; fruiting from September until October. Through Florida, excepting the tropical zone.

Material studied: **Fla.** Highlands Co., scrub section of the Botanical Garden, Highlands Hammock State Park, *R. Singer, F571;* Alachua Co. **Type** (*E. West* & *W. A. Murrill, F9561*).

A species easily recognized by its spores. It may be considered as belonging to the *Elephantinae* or *Chlorinae* (like *R. elephantina* = *R. mustelina*). The negative reaction with $FeSO_4$ and the color of the spores are distinctive in any section or subsection in which it may be placed.

RUSSULA ALBIDA Peck, Bull. N. Y. State Mus. 1 (2): 10. 1888. (Type.)

R. albida Peck has been studied previously, but the specimens were from the Kauffman Herbarium (MICH), and represent part of a collective species, *R. albida* Peck *sensu* Kauffman, containing the following elements: (1) *R. albida* Peck *sensu originali,* corresponding to the type at Albany; (2) a mild form, probably identical with *R. innocua* Sing.; (3) a somewhat acrid form, *R. anomala* Peck. My previous notes refer to this third element. As for the original *R. albida,* it may be said that it is also the one so identified by Beardslee, by Murrill, and others. The type specimens still show a distinct reaction with sulphovanilline and chlorovanilline very similar to that of *R. rosea* Quél. (*R. aurora sensu* Melz. & Zvára [3] and its smaller variety). The white pileus and the cream colored spore print in addition to the bitter taste make this the most unmistakable *Russula* known to me. The following revised description of the typical *R. albida* Peck is drawn from fresh specimens compared with the type.

Pileus white or whitish with the center sometimes tending to be pale cream colored, sometimes with brownish or ferruginous brown spots or specks, dry, rarely subviscid after prolonged rains, subglabrous to subvelutinous or like kid, convex, then with depressed center, with obtusely rounded margin which is smooth but eventually short (up to 3 mm.), sulcate in many specimens, the cuticle separable over one third to one half of the radius, diameter 25–60(110) mm. *Lamellae* white then cremeous, crowded or close, equal or nearly so, some bifurcate at the stipe, otherwise simple, broadest in the outer third (2–6, rarely up to 8 mm. broad), adnato-decurrent or somewhat decurrent; spore print B to C (Crawshay). *Stipe* white, dry, subglabrous, tapering downwards, or upwards, or ventricose, also often nearly equal, smooth, stuffed, then hollow, 25–90 × 7–11 mm., more rarely thicker, and up to 16 mm. broad. *Context* white, rather firm but not hard, unchanging; taste mild with a more or less (sometimes hardly noticeable) bitterish after-taste, always bitter in the cuticle; odor none.

[3] Schäffer was right in identifying *R. aurora* Krombh. *sensu* Bres. with *R. lepida* Fr. rather than with *R. rosea* Quél. An authentic specimen received by Burt from Bresadola (FH) reacts with sulphovanilline and chlorovanilline in about the same way as *R. Zvarae, i.e.,* normally; the epicutis shows some rather narrow dermatocystidia.

Spores 8.8–10.8 × 7.8–9.2 μ, mostly 10 × 8.7 μ, yellowish hyaline, with dense, coarse, cylindric spines, connected by fine lines that do not form a complete network (type IIIb, IV), more rarely isolated (V, VI), very rarely with short ridges (IIIb–II, IV–II), projecting 0.6–1.0 μ; *basidia* 34–38 × 10.8–13 μ, broadly clavate, 4-spored; *cystidia* rather numerous on edge and sides of gills, 62–82 × (6.7)10–14 μ, fusoid-ventricose, or fusoid with the thickest portion either near the middle or in the upper third or quarter, acute, usually short-appendiculate, with a fine granulosity (not banded) inside, not bluing in sulphovanillin; *primordial hyphae* on pileus and stipe present; surface of pileus with felty-interlaced, hyaline (in the brown spots brownish) hyphae with somewhat thickened walls (0.7 μ) and narrowly clavate ends (4–6 μ in diameter); *dermatopseudocystidia* none on pileus; all hyphae without clamp connections.

$FeSO_4$, on flesh of stipe normal (grayish-reddish). **Phenol,** slowly to "vinaceous purple," then "taupe brown." **Phenol-aniline,** red. **KOH,** on cuticle yellowish; otherwise negative. **Sulphovanilline,** "spectrum red," then "carmine." **Chloro-vanilline,** with dried context between "spectrum red" and "carmine" or more purely "spectrum red" for a short while, then slowly, through "Eugenia red" and "Amaranth purple," reaching "Indian lake."

Solitary or in groups in hammocks (high, mesophytic, low, and tropical), mixed woods, also in almost pure pine woods, either with pine (*P. australis,* or *P. palustris,* etc.), or with oak, either on the ground, especially on banks and in ditches, or on dead or living trunks, especially of *Sabal palmetto* sometimes several feet above the ground; fruiting from June until October. From New England to Florida (including the tropical zone), and west to Michigan and Alabama, perhaps farther west (western limits not established), increasingly frequent towards the south.

Material studied: **N.Y.** Sandlake. Type (NYS). **Pa.** Trexlertown, *Herbst* (FH). **N.C.** Asheville, *Beardslee* (FH). **Fla.** Fresh material from Dade, Highlands, and Alachua Co., *Singer* (FH); dried material seen from Alachua, Marion, and Levy Co., det. Murrill (FLAS).

This belongs to the *R. rosea* group of the subsection *Lepidinae* of the *Rigidae* Fr. I do not believe that *R. aurora* var. *cretacea* Melz. & Zvára, a bleached form of *R. rosea* in my opinion, is

identical with *R. albida*. The latter never shows the slightest trace of red, and can by no means be considered as a white form of *R. rosea*.

RUSSULA RUBESCENS Beardslee, Mycologia **6**: 91. 1914. (Type, and several fresh collections.) RUSSULA OBSCURA (Rom.) *sensu* Kauffman, Agar. Mich. **1**: 148. 1918. (Authentic material.) RUSSULA KAUFFMANIANA Sing., Bull. Soc. Myc. Fr. **55**: 258. 1939 (publ. 1940).

The strong influence Kauffman's concepts exercised on the opinions of those working on *Russula,* is due to the fact that he had, in general, a more concrete instead of abstract idea of the species, and his specimens are the ones most frequently exchanged and commented on. Considering the difficulty of this genus, and the enormous number of species occurring in Temperate North America, it is gratifying to see that Kauffman often, probably in a majority of cases, had the same concept about the species as expressed in the types. *R. rubescens* and *R. obscura* belong to that minority where Kauffman erred. In fact, *R. obscura sensu* Kauffman is so different from the European *R. obscura* = *R. vinosa* that the writer described it as a new species, *R. Kauffmaniana,* based on the authentic specimens from the Kauffman Herbarium (MICH, LE) of *R. obscura sensu* Kauffman. This was done under the presumption that *R. rubescens* Beardsl. is nothing but *R. vinosa* in the European sense. However, the type of *R. rubescens* reveals that it is the same as *R. Kauffmaniana,* and fresh material collected in New England as well as in the south by the writer has added the evidence, thus far lacking, needed for a full description of this common American representative of the *Decolorantinae*.

Pileus "Corinthian pink," "Corinthian red," "light Corinthian red," sometimes with some pale greenish ocher or chamois intermixed or partially bleached, sometimes much darker on the disc, subglabrous, subviscid when wet, sometimes partly subpruinose or very minutely subrimulose, with a smooth, or in age short-sulcate, subobtuse or obtuse margin, with the cuticle peeling moderately well except on the disc, opaque in fresh condition and sometimes

shining in dried condition, convex with depressed center, eventually concave, 34–70(85) mm. *Lamellae* stramineous-ochraceous, rather broad (6–8 mm. broad), close, attingent-subfree, equal, simple, but mostly connately-bifurcate at the stipe; spore print G (Crawshay). *Stipe* white, rarely with a reddish hue, becoming grayish (with "deep mouse gray" elevations on white ground), subrugulose, moderately firm, eventually very fragile, subequal, or tapering upwards with somewhat widened apex, stuffed, 30–50 × 6.5–15 mm. *Context* white, normally reddening before becoming dark gray, or immediately becoming gray stained, or entirely gray, becoming gray also in age and often on drying; taste mild; odor slightly fruity and at the same time of Camembert cheese.

Spores 8.8–11 × 7.5–9.5 μ, mostly 9.5–10 × 8.5 μ, short-ellipsoid to subglobose, yellowish, warty, ornamentation projecting 0.7–1.6 μ, consisting of cylindric spines, type VI, fewer IV, IIIb, IIIb–II, or IIIb–VIII, the connecting lines usually very fine; *basidia* 35–42 × 9–11 μ, clavate, more rarely tapering upwards from the thickest portion in the upper quarter, 4-spored; *pseudocystidia* 60–85 × 7–11 μ, fusoid, with the broadest portion at or more often above the middle and the tip acute, more rarely clavate, with yellowish banded contents, numerous on the sides and very numerous on the edges of the gills, bluing almost entirely in sulphovanilline; subhymenium of irregular, small elements, subcellular; *epicutis* of pileus made up of numerous, rather stiff and usually very straight dermatopseudocystidia of 30–90 × (4)6–8 μ, fusoid or more often clavate, their contents yellowish or hyaline, bluing in sulphovanilline; *subcutis* persistently pink in the purple portions of the pileus in NH_4OH offering a characteristic background for the usually yellowish dermatopseudocystidia.

Formalin with context, red.

Most frequently in low mixed woods near oaks, even in low hammocks, solitary or in small groups, from July until September. From New England south to Florida, and west to Michigan and probably Alabama and Tennessee.

Material studied: **Mass.** Arlington, *Singer* (FH); Wakefield, *Singer* (FH). **N.C.** Part of type (NY). **Fla.** Kelley's Hammock, Alachua Co., *Singer F2718* (FH). **Mich.** Authentic material of *R. obscura sensu* Kauffman (MICH).

This species is easily distinguished from *R. vinosa* by the ratio between the length of the spines of the spores and the diameter of the spores without ornamentation, also by the characteristic struc-

ture of the epicutis, the habitat, and the smaller size, to a certain degree also by the color.

RUSSULA CONGOANA Pat., Bull. Soc. Myc. Fr. **30**: 336. 1914. (Type.)

The type specimen from Kaga M'bra, French Congo, coll. M. Baudon, June 6, 1912, No. 1666, is colored like the red form of *R. Mariae* Peck; its pigment on the pileus and stipe is dissolved. The spores are 8.5–11.5 × 7.5–9.5 μ, asymmetrical, with 0.7–1.1 μ high ornamentation of type II, or II–IIIa; in the hymenium of the lamellae, there are numerous broadly clavate pseudocystidia with yellow amorphous contents (and it might be that these are the cause for the yellow color of the lamellae; the spores are not strongly pigmented, yet, when carefully compared with those of *R. emetica,* they appear slightly yellower), 39–70 × 12–14 μ; pileus with rather numerous dermatopseudocystidia, filled with banded contents, 39–41 × 7.5–8.8 μ. The lamellae are pale yellow as perhaps in dried *R. integra* = *R. Velenovskyi;* a spore print was not obtained by the collector, and it can only be estimated (B, C, or D); the margin is not distinctly acute, probably obtuse, slightly sulcate but neither pectinate nor grooved-plicate. This appears to be a representative of the section *Constantes,* probably belonging to one of the following subsections: *Emeticinae, Sardoninae,* or *Integrinae* (as used in my monograph). It would be desirable to learn about the taste of this species which according to the microscopical characters one would expect to be acrid.

RUSSULA ABIETINA Peck, Ann. Rep. N.Y. State Mus. **54**: 180. 1901. (Type.)

The type collection of *Russula abietina* as preserved in Albany consists of several specimens in good condition. These specimens are not all the same thing, and no particular fruiting body has been designated as the type specimen.

One element of the type collection is a species with spore ornamentation of type IIIa, more rarely IIIb which is only 0.5–0.7 μ high on an average while occasional larger spines do occur; in this form the general measurements of the spores are 7.5–9 × 5.7–7.2 μ.

This part of the type is macro- and microscopically identical with *R. Blackfordiae* Peck which we have shown to be the same as *R. serotina* Quél. *sensu* Melzer & Zvára, or *R. versicolor* J. Schäffer.

The other part of the type collection has larger spores (9.3–11 × 8.5–9.2 μ) with higher (1.0–1.4 μ) ornamentation which is less reticulate and more variable, most frequently belonging to type IV, or V–VI, or IIIb, sometimes showing catenulate lines (VIII). This part of the type collection is macro- and microscopically identical with the white-stemmed form of *R. sphagnophila,* described as var. *subingrata* on the basis of Czechoslovakian specimens by this writer in 1931. It was also found (authentic specimens at the Farlow Herbarium) in the Adirondack Mts., N.Y., by the writer in 1941, immediately recognized as *R. sphagnophila* Kauffman (by the way, also the red stemmed form was found there, and it had the same spore size as found in Europe), and it occurred invariably near birches. In most balsam fir woods of this mountain district here as well as in New England, various species of *Betula* may be mixed in. This is the explanation of the otherwise puzzling indication of the habitat by Peck. As in Europe, var. *subingrata* has slightly more frequently connected warts on the spores than the type variety, and the taste varies from entirely mild to very slightly acrid in youth, especially in the lamellae. It is, nevertheless, not always quite clearly separated from the type variety, yet it is different enough to puzzle and mislead good specialists of the genus like Peck, Burlingham, Kauffman who even put the type and the variety in different sections.

The type collection, being a mixed collection, *R. abietina* becomes a *nomen ambiguum* and has to be abandoned in favor of *R. Blackfordiae* Peck and *R. sphagnophila* Kauffm.

R. Maire has reported this species from Europe, and the writer has reported it from the Pacific Coast. If Maire's concept of *R. abietina* is that of Peck, *i.e.,* a sum of *R. Blackfordiae* and *R. sphagnophila,* the fact of its occurrence in Europe would not be surprising since both these species are known to occur there. However, Maire's remarks on his *R. abietina* (habitat under *Pinus* and *Picea;* comparison with *R. nauseosa* and *R. puellaris;* also the fact that Maire indicates *R. versicolor* = *R. Blackfordiae* and *R. venosa* = *R. sphagnophila* at the same time and as different spe-

cies) would rather lead to the conclusion that *R. abietina sensu* R. Maire *non* Peck is the same as *R. nauseosa* (Pers. *ex* Fr.) Fr. as understood by most European authors including this writer.

My *R. abietina* Peck *sensu* Singer *non* Peck, Bull. Soc. Myc. Fr. **54**: 157. 1938 is also not the combination of forms so named by Peck but an autonomous species occurring only in the Pacific Coast States, the correct name of which may be *R. placita* Burl. What I described as *R. Turci* in Europe (1926, 1932) and identified with *R. abietina sensu* Sing. *non* Peck in 1938, is extremely similar to the latter, yet, as more material (from E. E. Morse and from A. H. Smith, with more specimens, notes, and a color stereophotograph) shows, cannot be considered as conspecific with it. It appears that *R. Turci* Bres. is represented in the herbaria by numerous collections which seem to belong to different species, and have been interpreted differently in the literature though the earlier interpretation (Maire, J. Schäffer) has not been recognized by Bresadola. We now consider *R. Turci* Bres. as another *nomen ambiguum,* and propose the new name **Russula neglecta** Sing. nom. nov. (*R. Turci* Bresadola *sensu* Sing. *non* Maire *nec* J. Schäffer) for our interpretation, with the type being the collection sent by Bresadola to New York Botanical Garden (see Mycologia **34**: 91. 1942). I suspect that this species is hiding in what J. Schäffer now calls "Das Problem *R. chamaeleontina* Fr." (Ark. f. Bot. **29A**: 39–42. 1939). It may well be that the pseudodermatocystidia of the pileus are inconstant (they are certainly not too abundant in my specimens), and accompanied by primordial hyphae. This, if true, would explain my own share of error in the history of *R. neglecta.*

RUSSULA MURRILLII Burl., Mycologia **5**: 310. 1913. (Supplementary data on type.)

Though I cannot discover any anatomical or external difference between this and the European-Asiatic *R. punctata* Krombh. *sensu* Sing. = *R. amethystina* Quél. *sensu* J. Schäff., excepting the spore color, I feel my conclusion on the type specimen (Mycologia **34**: 77. 1942) is misleading and needs to be modified. In spite of the fact that the type, as a specimen, has all visible characters in

common with *R. punctata,* and seems to be identical with specimens of the latter, it may nevertheless be a subspecies or a closely related species. Newly arrived material which I owe to Dr. Alexander H. Smith was accompanied with a good color stereophotograph and thick spore prints. The fresh fruitbodies look entirely like *R. punctata* but the spore print is from C–D to D–E (Crawshay) and near "warm buff" of Ridgway in tone, thus definitely lighter colored than the spore print of *R. punctata.* This difference can hardly be explained by variability, and even so, such variability in one region would at least suggest a subspecies; if any character—perhaps chemical—could be discovered that is constantly correlated with lighter colored spores, *R. Murrillii* might very well be considered as autonomous.

RHODOGONIOSPORACEAE

CLAUDOPUS CYANEUS Murr., Mycologia **35**: 429. 1943. (Type; also fresh material compared with it.)

Pileus between "Indigo blue" and "dusky blue," smooth, subtomentose-subfibrillose, especially near the zone of attachment, dimidiate, from 6 mm. (up to 20 mm. according to Murrill) in diameter. *Lamellae* paler blue, soon with pink spore dust, subdistant to distant, rather broad (up to 2 mm. in medium sized specimens). *Stipe* concolorous, subglabrous, very eccentric, sublateral, 2–3 × 1–1.5 mm. *Context* pallid, very thin; taste farinaceous but not bitter; odor farinaceous.

Spores 8–10.7 × 5.5–7 μ with (5)–6 angles or nodules, with suprahilar depression, the lower end in frontal view rectangular (symmetric type of Romagnesi); *basidia* 40 × 10 μ

Our own collection was on wood of *Ostrya virginiana* in a mesophytic hammock southwest of Gainesville, Fla., July 1, 1943 (F 2480).

The new combination **Rhodophyllus cyaneus** (Murr.) Sing. comb. nov. is proposed for this species. It belongs in what I have called the subgenus *Eccilia* of *Rhodophyllus* which also contains the other small, pleurotoid species such as *R. depluens* (Batsch *ex* Fr.) Quél. (also common in Florida, even on tropical hosts such as *Ficus aurea,* etc.), and *R. byssisedus* (Pers. *ex* Fr.) Quél.

Entoloma cyaneum Peck, a very striking species that also be-

longs in the genus *Rhodophyllus,* was first described by Peck as *Agaricus cyaneus* Peck *non* Persoon *nec* Secretan. It is a homonym and should be called **Rhodophyllus violaceus** (Murr.) Sing. comb. nov.

SCUTIGERACEAE

DIACANTHODES PHILIPPINENSIS (Pat.) Sing. Lloydia **8**: 141. 1945. (Type, as *Daedalea.*) ABORTIPORUS SUBABORTIVUS Murr., Bull. Torr. Bot. Club **65**: 655. 1938. (Type.)

Pileus light fulvous to fulvous brown, slightly to strongly coarsely rugose to toothed by spines, sometimes with concentrically arranged rugosities or obtuse elevations, not zonate in the manner of the *Corioli,* subglabrous, with more or less broadly sterile margin, context soft but not actually fleshy, consisting of a comparatively thin upper layer that is loosely felty, the thicker, lower layer more compact, more white and often separated from the upper layer by darker cartilaginous lines in dried material; odor none, taste mild; diameter of the pileus up to 150 mm. *Pores* white, small (0.5 mm. broad or even narrower) but rather angular, unchanging; tubes with thin, tender walls, 1.5–3 mm. long, decurrent, edges even, later denticulate. *Stipe* concolorous-paler, eventually a deep cinnamon color, subglabrous or glabrous, smooth or somewhat rough, eventually polished, subequal or irregular, with a pseudorrhizal proliferation (crypts) on the substratum, 45–90 × 12–45 mm.

Spores 6.5–8.8 × 5.5–7 μ, with cylindric, thin, non-amyloid 0.7–1.4 μ long spines, walls thin, non-amyloid but occasionally very slightly pseudoamyloid (?), yellowish-hyaline in KOH, with or without an indistinct hyaline perisporium that sometimes covers the lower half or all of the spines, subglobose, always abundant; the hilar appendage asymmetrically attached; in print white or whitish; *basidia* 15–32 × 8–8.5 μ, short and thick, clavate, often with very strange hook-like excrescences on the side of the apex; *cystidia* none, but deformed sterile basidia (pseudoparaphyses) scattered, 20–30 × 7.8–8.2 μ, frequently fusoid with obtuse apices; hyphae of the *subhymenium* with very crowded septa, short-cylindric; *hyphae* of the hymenophoral trama thick-walled to thin-walled (toward the terminal members of hyphae-chains thinner-walled), non-amyloid; clamp connections numerous.

The above description is based on our own collections from the Matheson Hammock, Dade Co., Fla. (F 757) where it grew in a tropical hammock on the ground above lime rock but the mycelium

was visibly connected with the roots of *Bursera simaruba.* It is therefore not surprising to find the habitat of *D. philippinensis,* type, indicated as rotten wood. The colors, the appearance, size and pore characters, the quality of the surfaces, and also all the microscopical characters are virtually identical in my Florida specimen, in Murrill's and in Patouillard's type, and also in a Brazilian collection.[4] The genus *Diacanthodes* is intermediate between *Bondarzewia*[5] and *Abortiporus.*[6]

FARLOW HERBARIUM,
HARVARD UNIVERSITY,
CAMBRIDGE, MASS.

[4] Murrill, defending his species (Mycologia **37**: 793. 1945), says that in *D. philippinensis,* the color and zonation of the pileus are different, the stipe longer and varnished, and the spores larger and echinulate instead of minutely rough as indicated by Murrill. Patouillard described his specimen from the dried condition, and his description "cremeo dein fuscentente" (not cream to fuscous) and "azono" is not too far off, at least for many of our specimens. The same is true for the size and surface of the stipe. As for the spores, I found them up to $8.5 \times 7.5\,\mu$ in Murrill's type and the spines exactly as described above. Murrill's measurements are too low (under an oil immersion lens, the ornamentation included) at least for mature spores. The fact that a species described from Florida falls in synonymy with a little known species from the Philippines does not reflect in any way upon the author of the synonym. These things are bound to happen from time to time, and we should keep in mind that the establishment of the synonymy in type studies is an important help to future taxonomists because it simplifies their task.

[5] *B. montana* (Quél.) Sing.; *B. Berkeleyi* (Fr.) Bond. & Sing.

[6] *A. distortus* (Schw.) Murr.; *A. borealis* (Vahl *ex* Fr.) Sing.; *A. humilis* (Peck) Sing.; *A. Peckianus* (Cooke) Sing. (*Polyporus Peckianus* Cke.); *A. dealbatus* (Berk. & Curt.) Sing. (*Polyporus dealbatus* B. & C.).

A NEW SPECIES OF CONIOTHYRIUM PARASITIC ON SCLEROTIA

W. A. CAMPBELL [1]

(WITH 1 FIGURE)

In the investigation of Sclerotinia disease of guayule in a plantation near Salinas, California, isolations were made either from diseased root tissue or associated sclerotia from approximately 200 infected plants. Pure cultures of either *Sclerotinia minor* Jagger or *S. sclerotiorum* (Lib.) D. By. were obtained from the majority of these infected plants. However, in two instances the sclerotia of *S. sclerotiorum* produced in Petri dish cultures became covered with the pycnidia of a contaminating fungus after three to four weeks at room temperature. Pycnidia were confined to the sclerotia and did not develop on the mycelial mat. The contaminating fungus was readily obtained in pure culture and was identified as a species of *Coniothyrium*. Preliminary inoculation experiments wherein pycnidiospores were placed on sclerotia of *S. sclerotiorum* demonstrated that the fungus was parasitic. The biological control of one fungus by another is always an interesting possibility; therefore, further inoculation experiments as well as studies on the cultural and morphological characters of the fungus were conducted.

In January, 1946, a collection of sclerotia of *Sclerotinia sclerotiorum* was made from diseased Brussels sprouts. These sclerotia and others produced on sterile oats were buried in sterile sand and maintained under suitable moisture and temperature conditions for apothecial formation. Twenty-five sclerotia from Brussels sprouts were buried in one-half of each wooden flat and twenty-five sclerotia from sterile oats in the other half. After approximately three months apothecial development had ceased and the sclerotia were recovered from the fifteen flats by washing the sand through a fine

[1] The assistance of R. E. Bardin, R. W. Davidson, L. C. Erickson, H. N. Hansen and W. C. Snyder in the course of this study is hereby gratefully acknowledged.

screen. Two hundred and eighty of the sclerotia from Brussels sprouts were recovered in various stages of preservation. Thirteen of these from nine of the fifteen flats were covered with pycnidia of *Coniothyrium*. Parasitized sclerotia disintegrate readily; therefore, the thirteen sclerotia having pycnidia of *Coniothyrium* probably represented only a portion of those actually parasitized. None of the sclerotia from sterile oats was parasitized by *Coniothyrium*. The presence of *Coniothyrium* on the sclerotia from Brussels sprouts and its absence in the same flats from those produced on sterile oats is assumed to be evidence that some of the sclerotia from the first-named source were either infected or had spores of *Coniothyrium* on them at the time they were collected.

Inasmuch as the fungus parasitic on sclerotia does not conform to the description of any known species of *Coniothyrium*, it is herein described as a new species.

Coniothyrium minitans n. sp.

Pycnidia globosa, superficialia, basi angusto affixa, levia, muro atro carbonaceo praedita, 200–700 μ in diam., ostioli centrali plerumque sporis exsudis obscurato; pycnidiosporae in massa atra liquida exsudantes, brunneae, ellipsoideae, leves vel in vetustate minute asperatae, 4–6 × 3.5–4 μ. Sclerotia *Sclerotinia sclerotiorum* in California parasitans.[2]

Pycnidia globose, superficial, attached by a narrow base, smooth with a black carbonaceous covering, 200–700 μ in diameter; ostiole centrally located, usually obscured by exuded spores; pycnidiospores exuding as a black liquid mass, individual spores brown, ellipsoid, smooth or minutely roughened with age, 4–6 × 3.5–4 μ. Parasitic on sclerotia of *Sclerotinia sclerotiorum*.

The type specimen on sclerotia of *Sclerotinia sclerotiorum* collected on diseased Brussels sprouts, January 1946 near Carmel, Monterey Co., California, has been deposited with the Division of Mycology and Disease Survey, Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture.

DESCRIPTION IN CULTURE

The pycnidiospores germinate readily on potato-dextrose agar or water agar and all cultural studies were made from single spore

[2] Latin description prepared by Edith K. Cash, Associate Mycologist, Division of Mycology and Disease Survey.

cultures. The fungus grows slowly on Difco potato-dextrose agar forming in seven days a mat 30 to 35 mm. in diameter at room temperature from 20 to 25° C.; mat white, azonate, curly cottony to woolly with denser tufts near the center which are pycnidial initials; margin narrow, appressed, finely fimbriate.

In fourteen days mat from 60 to 70 mm. in diameter with a distinct central zone covered with numerous superficial dark colored pycnidia or with lighter pycnidial initials buried in the fine woolly surface mycelium; outer zone wide, white, azonate.

With further aging the mat surface becomes covered with numerous uniformly spaced dark pycnidia, these variable in size, ranging from 160 to 600 μ in diameter; the pycnidiospores exude from the pycnidia as a black liquid mass and correspond in size and shape with those described for spores produced on sclerotia (FIG. 1, *C*). The undersurface of the mat is dark only in numerous spots corresponding to location of pycnidia on the surface. Hyphae from growing margin of culture are 2–6 μ in diameter,

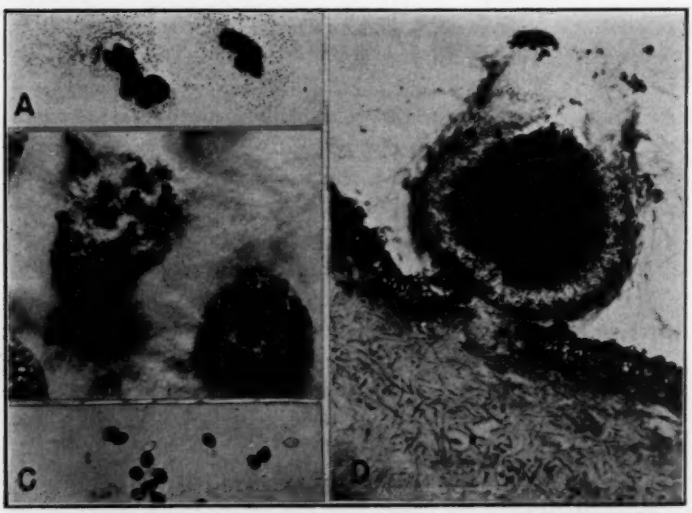

FIG. 1, *A–D, Coniothyrium minitans. A,* Pycnidia that developed on filter paper around parasitized sclerotia of *Sclerotinia sclerotiorum. B,* Pycnidia on sclerotia of *S. minor* in a Petri dish culture. *C,* Pycnidiospores. *D,* Cross-section of pycnidium on the surface of a parasitized sclerotium of *S. sclerotiorum.*

smooth, simple, with numerous septations common in the larger hyphae; in older parts of culture yellowish, roughened hyphae occur.

Growth at constant temperatures on Difco potato-dextrose agar expressed as radial growth in millimeters in seven days in dark as follows: 10° C., 4 mm.; 15°, 12 mm.; 20°, 20 mm.; 25°, 4 mm.; 30°, no growth.

INOCULATION EXPERIMENTS

In a laboratory inoculation experiment large sclerotia of *Sclerotinia sclerotiorum* produced on sterile oat cultures were placed on moist sterile blotting paper in Petri dishes. A droplet containing *Coniothyrium* spores in suspension was placed on the surface of each sclerotium. The sclerotia were then incubated in the laboratory at room temperature. In ten days the sclerotia and adjacent blotting paper were covered with pycnidia of *Coniothyrium minitans* (FIG. 1, *A*). On sectioning a parasitized sclerotium the structure of the pycnidium and the ramifications of the mycelium of *Coniothyrium* in the sclerotium could be clearly noted (FIG. 1, *D*). The parasitized sclerotia had lost their firm texture and become soft, and disintegrated readily when handled.

In another inoculation experiment a spore suspension of *Coniothyrium* was spread over sclerotia of both *S. sclerotiorum* and *S. minor* growing in pure culture in Petri dishes. Pycnidia quickly developed on the surface of the sclerotia (FIG. 1, *B*). Pycnidia did not develop on the mycelium, and the fungus appeared to be present only on the sclerotia.

In a third inoculation experiment, which was started on December 6, 1945, sclerotia of *S. sclerotiorum* produced on sterile oat cultures in the laboratory were used. The check or treatment *1* consisted in burying twenty-five sclerotia of comparable size ½ inch deep in sterile sand in four small wooden flats. Two of the flats were maintained on the greenhouse floor at temperatures ranging from 50 to 75° F. and the remaining two were placed outside on the north side of the greenhouse where the temperatures varied from 30 to 65° F. Treatment *2* consisted in immersing the sclerotia in a spore suspension of *Coniothyrium minitans* after which they were buried ½ inch deep in sterile sand. In treatment *3*, the sclerotia were first buried, after which the surface of

the sand was watered with a suspension of *Coniothyrium* spores. In both treatments *2* and *3*, as in the checks, twenty-five sclerotia were used per flat and two replications of each were maintained in the greenhouse and two outside. The flats were watered daily in order to provide optimum moisture conditions for the formation of apothecia.

Apothecia first appeared on January 10, 1946, in the check flats kept in the greenhouse and the peak of development was reached on February 25 (Table 1). During this period no apothecia developed in treatment *2* but a considerable number appeared in replication *A* of treatment *3* and a lesser number in replication *B*. However, apothecial formation was of shorter duration than in the check and by March 19 the apothecia had disintegrated almost completely. The experiment inside the greenhouse was terminated on this date and the sclerotia recovered by washing. All sclerotia in treatment *2* had softened, the outer dark colored coating came off in the washing process and only the pink, gelatinous inner tissues of a few sclerotia were recovered. Many of the sclerotia had turned into a dark mass of *Coniothyrium* spores. In treat-

TABLE 1

APOTHECIA PRODUCTION BY SCLEROTIA OF SCLEROTINIA SCLEROTIORUM INOCULATED WITH SPORES OF CONIOTHYRIUM MINITANS

Treatment	Replicates	Number of Apothecia Present on:								
		1/17	1/24	1/30	2/5	2/17	2/25	3/12	3/19	4/2
In greenhouse:										
1. Check	A	7	17	18	31	53	58	27	46	—
Check	B	1	3	3	6	37	57	49	27	—
2. Spores on sclerotia	A	0	0	0	0	0	0	0	0	—
Spores on sclerotia	B	0	0	0	0	0	0	0	0	—
3. Spores on soil surface	A	0	0	0	3	20	21	13	1	—
Spores on soil surface	B	0	0	0	0	2	2	1	0	—
Outside greenhouse:										
1. Check	A	0	0	0	0	0	7	77	82	84
Check	B	0	0	0	0	0	13	84	78	79
2. Spores on sclerotia	A	0	0	0	0	0	5	12	11	11
Spores on sclerotia	B	0	0	0	0	0	1	4	1	0
3. Spores on soil surface	A	0	0	0	0	0	16	28	24	24
Spores on soil surface	B	0	0	0	0	0	11	22	27	23

ment *3*, the sclerotia were likewise badly softened with the exception of the few that produced apothecia. The sclerotia in the checks were firm and a number were still producing apothecia.

Apothecial formation was much slower in the flats kept outside the greenhouse than in those maintained within, because of the lower outside temperatures. The first apothecia did not develop until February 17, or more than a month after those kept at more favorable temperatures. However, the peak of production was reached in a shorter period and more apothecia were produced in the checks and in treatments *2* and *3*. Inasmuch as *Coniothyrium minitans* grows best at 20° C. or approximately 68° F., it would seem that its ability to parasitize sclerotia was affected by temperature. However, even at the lower temperatures prevailing outside the greenhouse it caused a marked reduction in apothecial production when the surface of the sand was inoculated by a spore suspension. The apothecia that formed in treatments *2* and *3* developed brownish spots that appeared to be areas parasitized by *Coniothyrium*. No such spots appeared in the checks. When the sclerotia were recovered by washing, those in treatments *2* and *3* were uniformly softened and disintegrated in contrast to the firm but shriveled condition of those in the checks.

SUMMARY

Coniothyrium minitans was isolated from parasitized sclerotia of *Sclerotinia sclerotiorum* obtained from Sclerotinia-diseased guayule from near Salinas, California, and from Brussels sprouts from near Carmel. Laboratory inoculation experiments demonstrated that sclerotia of both *S. sclerotiorum* and *S. minor* were readily parasitized by the fungus and furnished suitable substrata for the development of pycnidia. In an inoculation experiment the formation of apothecia from sclerotia of *S. sclerotiorum* in sterile sand was suppressed when pycnidiospores of *C. minitans* were brought in direct contact with sclerotia and when they were poured on the surface of the sand. The results of these experiments suggest the possibility of biological control of *Sclerotinia* spp. by *C. minitans*.

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INCREASED PERITHECIUM FORMATION AND HYBRIDIZATION IN FLOODED CULTURES OF A HOMOTHALLIC ASCOMYCETE

SHUH-WEI HWANG, H. N. HANSEN, AND WILLIAM C. SNYDER

(WITH 1 FIGURE)

While studying variation phenomena in a homothallic form of *Hypomyces solani* (Rke. et Berth.) Snyder et Hansen, Hwang (**1946**) noted that perithecia were formed sooner and in greater abundance when full-grown cultures in test tubes were flooded with sterile water to obtain conidia for single-spore transfer (FIG. 1). A similar response in perithecium production was obtained by flooding full-grown cultures of *Gibberella roseum* (Lk.) Snyder et Hansen. This observation indicated a means by which perithecium formation may be induced with regularity and in increased amounts in such homothallic ascomycetes where otherwise it is erratic or scant. The procedure has since proven useful in studies on the ascigerous stages of these fungi.

This behavior of cultures following flooding, suggested that fertilization in these and perhaps in other homothallic ascomycetes may take place through a trichogyne or flexuous hypha. Furthermore, it suggested the possibility of hybridizing such forms by flooding cultures with spore suspensions from other thalli. The flooding technique has been used successfully by Dimock (**1937**), and by Hansen and Snyder (**1943**) in hybridizing heterothallic forms of *H. solani*, and by Dodge (**1932**) and others in various heterothallic ascomycetes.

Accordingly, four-week-old cultures of the wild type, *N*, of homothallic *H. solani*, were flooded with a conidial suspension of a distinctive mutant, *El*. This *El* type had never been observed by Hwang (**1946**) to arise directly from *N*, but only secondarily from a primary mutant, *B*. Other cultures of *N*, flooded with sterile water, served as controls.

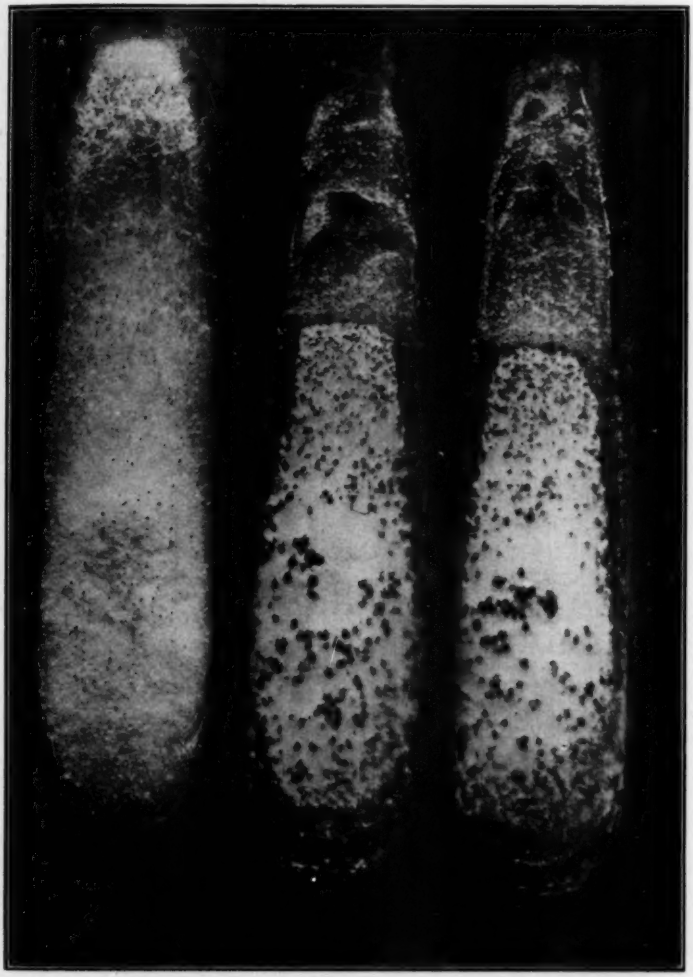

FIG. 1. The two cultures on the right were flooded with sterile water whereas that on the left was not treated. Note the marked increase in perithecium production on the right.

Mature perithecia were obtained in about a week on all flooded cultures. Four single-ascospore transfers were made at this time from each of a number of perithecia from cultures treated in both ways. The precaution was taken to examine each single ascospore under the compound microscope at the time of its transfer. Results of the ascosporic analysis $N \times El$ are shown in table 1.

TABLE 1

SINGLE ASCOSPORE ANALYSIS OF THE CROSS $N \times El$, IN HOMOTHALLIC *H. solani*

Progeny	No. of Perithecia Tested																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
N	4	4	3	4	4	4	3	3	0	4	2	0	0	4	3	4	46
El	0	0	1	0	0	0	1	1	4	0	2	4	4	0	1	0	18

Thus when *El* was applied as functional male to *N*, it was recovered by means of ascospores 18 times out of a total of 64 monoascosporic transfers representing 16 perithecia. A similar number of monoascosporic cultures from perithecia of *N* flooded only with sterile water yielded no *El*. Although *El* has been recovered in several tests from the cross $N \times El$, so far hybridization in the reciprocal cross $El \times N$ has failed to occur.

In subsequent tests a modification of the flooding technique was adopted. This consists in spraying the culture with sterile water, or a spore suspension as the case may be, by means of a sterilized DeVilbiss atomizer the air vents of which have been loosely plugged with cotton. One to three discharges of the spray into the culture have given better and more normal perithecium development with less matting of the fungus growth than has flooding.

Whereas hybridization of homothallic *H. solani* has been accomplished repeatedly by the flooding and spraying techniques, it has resulted only rarely from the familiar hybridization procedure of pairing thalli and allowing the colonies to approach each other or by permitting the mycelia to intermingle from the start. This pairing method used successfully for other fungi has not only proven inferior in hybridizing either the homothallic or heterothal-

lic forms of *H. solani* but has failed to insure adequate perithecium development in them.

Hybridization in homothallic forms of this kind provides an additional approach to a study of their genetic constitution and inheritance.

SUMMARY

Flooding or atomizing full-grown cultures of a homothallic form of *Hypomyces solani* with water alone hastened and increased perithecium formation. By applying conidial suspensions in both of these ways hybridization between two cultural strains was effected.

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MICROSPORUM AUDOUINI: THE EFFECT OF YEAST EXTRACT, THIAMINE, PYRIDOXINE, AND BACILLUS WEIDMANIENSIS ON THE COLONY CHARACTERISTICS AND MACROCONIDIAL FORMATION *

ELIZABETH L. HAZEN

(WITH 4 FIGURES)

The dermatophytes consist of three genera, *Microsporum, Trichophyton,* and *Epidermophyton,* characterized by distinctive cultural and morphologic characters. *Microsporum* is represented by flat, spreading, fluffy, downy or powdery growth, varying in color from white to tan; by single-celled clavate microconidia; and by long spindle-shaped macroconidia with few to many septa. The genus consists of at least three species, *Microsporum canis* (*lanosum, felineum*), *Microsporum gypseum* (*fulvum*), and *Microsporum audouini. Microsporum canis* and *Microsporum gypseum* grow luxuriantly and produce macroconidia abundantly on Sabouraud's dextrose, maltose, or honey agar. Specific identification of *Microsporum audouini,* however, cannot always be made on these media because growth is sparse and macroconidia are produced irregularly or not at all.

Sabouraud (1) obtained heavy growth and found macroconidia in *Microsporum audouini* on dextrose and maltose agars. Conant (2) discovered that species of *Microsporum* of animal origin grew profusely on polished rice grains and produced macroconidia in

* This work was done in the Department of Dermatology, College of Physicians and Surgeons, Columbia University, in association with Dr. Rhoda Benham to whom I wish to express thanks for advice and suggestions throughout the study.

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abundance, but that *Microsporum audouini* grew poorly, showing no aerial growth and producing no macroconidia. Benedek (3) found, accidentally, that a culture of *Microsporum audouini* contaminated with a bacillus that he named *Bacillus weidmaniensis* grew well on polished rice grains and produced long, thick-walled septate and non-septate spindle-shaped spores. He had no difficulty in confirming his observation with pure cultures of *Microsporum audouini* inoculated on rice grains to which the bacillus was added. The growth of *Microsporum audouini* with production of macroconidia on polished rice grains infected with *Bacillus weidmaniensis* has been confirmed by Dr. Rhoda W. Benham (unpublished data).

This stimulation by *Bacillus weidmaniensis* of the growth of *Microsporum audouini* with production of macroconidia naturally raised the question as to the nature of the growth-promoting substances. The presence of the nutritional factors, produced by the actively-growing bacillus, suggested that they might be of the nature of vitamins and for this reason the study of yeast extract, as well as some of the single vitamins of the B complex, for their growth-promoting properties for *Microsporum audouini,* was undertaken. The results of the preliminary study of the problem are presented herein.

METHOD

Eighteen pure cultures of *Microsporum audouini,* recently isolated from the scalp of children who came to the Vanderbilt Clinic for treatment for *Tinea capitis,* were used. Honey agar, pH 5.5, containing 60 grams of commercial honey, 10 grams of peptone, 20 grams of agar and 1000 ml. of distilled water, and autoclaved at fifteen pounds pressure, was adopted as a basal medium to which were added the substances under investigation. This medium was recognized not to be vitamin-free, but it seemed a desirable one for the preliminary investigation since it is satisfactory for isolation, but unsuitable as a single medium for specific identification of *Microsporum audouini.*

The following substances were tested for their effect upon growth and macroconidia production particularly: Yeast extract, thiamine,

pyridoxine, thiamine and pyridoxine, and polished rice grains inoculated previously with *Bacillus weidmaniensis*. Bacto-yeast extract, a dehydrated Difco product, was used. A fresh five per cent solution was prepared in sterile distilled water and passed through a Berkefeld filter. The filtrate was added to the basal medium (cooled to approximately 45° C.) in an amount equal to 5 mg. of yeast extract per ml. of medium. Fresh solutions of the yeast extract were prepared for each series of experiments. Solutions of thiamine chloride and pyridoxine hydrochloride were prepared aseptically in sterile distilled water, and these were added, respectively, to the basal medium in amounts equal to 0.5 γ to 1 γ per ml. of medium. Sterile polished rice grains in 250 ml. flasks were inoculated with two or three loopfuls of a fresh culture of *Bacillus weidmaniensis* on honey medium. They were left at room temperature for forty-eight or seventy-two hours so as to have good growth of the bacillus on the surface of the rice grains at the time of inoculation with the fungus.

The original primary cultures of *Microsporum audouini* on honey, dextrose, or maltose agar served, in the majority of instances, as the seed culture for the experimental media. (The cultures were maintained on honey agar.) In none of the primary cultures examined microscopically were macroconidia found. Small inocula of the seed culture were placed in the center of Petri dishes containing about 30 ml. of medium and left at room temperature for eight weeks or longer. The cultures were usually inoculated in duplicate, and microscopic examinations were made of film preparations for the presence of macroconidia, when they were about three weeks old and, thereafter, at weekly intervals, as far as possible, for from six to eight weeks. Bits of the fungus were taken from the plate, placed on a slide in sodium hydroxide-glycerol solution, and teased apart with a dissecting needle; over these a cover slip was dropped. Such preparations were then searched carefully for macroconidia and a count was made. The number of macroconidia in a culture was roughly estimated from the number found in the film preparations on the particular date.

Eighteen cultures were studied on both honey agar and honey agar plus yeast extract, but only nine of them were studied with

the vitamin combinations and with polished rice grains, and rice grains inoculated with actively growing *Bacillus weidmaniensis.*

EFFECT OF YEAST EXTRACT

Macroscopic.—The growth on honey agar to which yeast extract had been added was heavier and resembled more closely than that on honey agar alone, Sabouraud's (**2**) description and

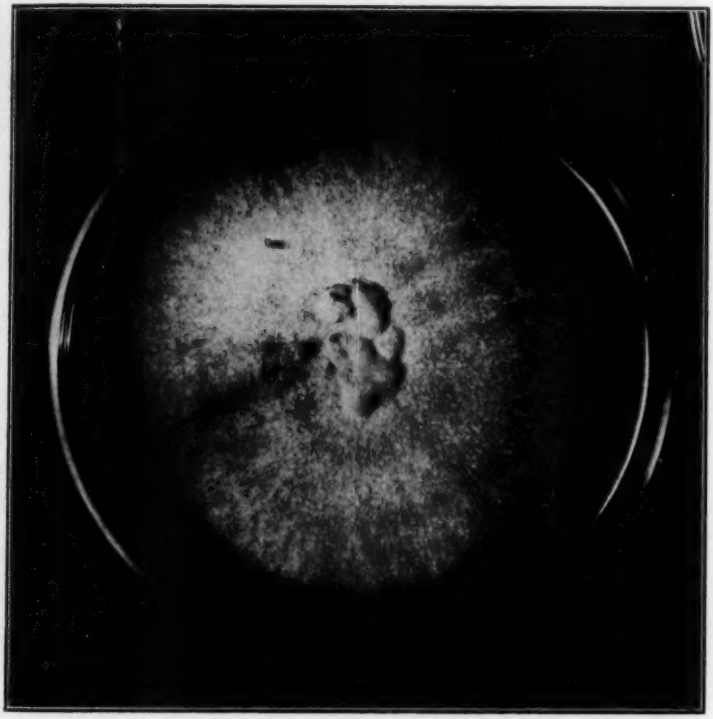

FIG. 1. *Microsporum audouini,* honey agar, 24 days.

photographs of *Microsporum audouini* on dextrose and maltose agar. The typical colony on honey agar is flat with scanty, grayish white, aerial mycelium, and on the reverse side shows a rose-brown pigment; with the addition of yeast extract, a typical colony showed

a heavy, grayish-white, decumbent mycelium and deep radial grooves, and on the reverse side prominent concentric circles and a deep rose-brown pigment (FIGS. 1 and 2). When a different brand of peptone was used, the colonies varied in that the aerial mycelium was not so heavy and the radial furrows were shallow or lacking. This phenomenon requires investigation.

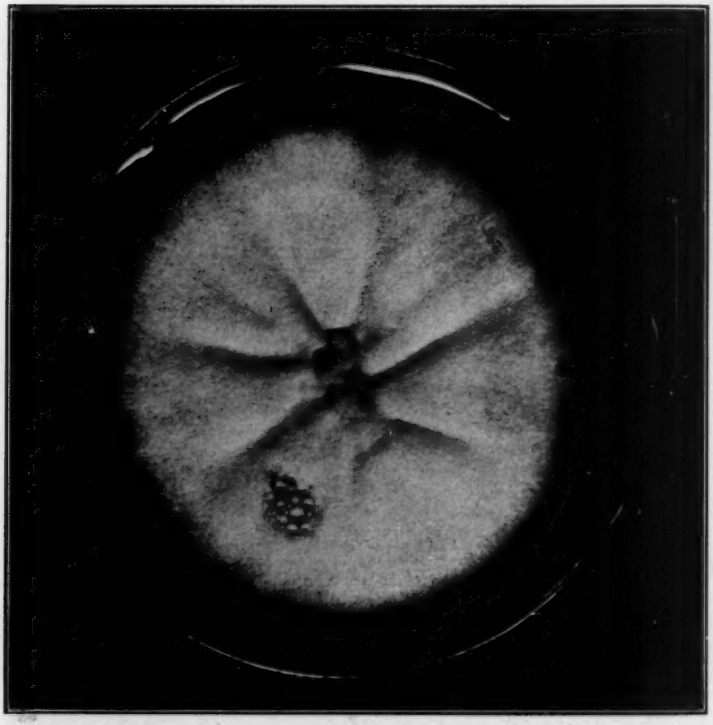

FIG. 2. *Microsporum audouini*, honey agar plus yeast extract, 24 days.

Microscopic.—In only four of the eighteen cultures were macroconidia found on honey agar and in only one instance in appreciable numbers, whereas with the addition of yeast extract all but one culture produced macroconidia (Table I). Nine showed a count of from six to ten or more macroconidia in a culture mount,

TABLE I

MACROCONIDIAL FORMATION OF M. AUDOUINI ON VARIOUS MEDIA

Culture No.	Estimate of Number of Macroconidia in Culture*							
	Approx. Age of Culture (wks.)	Honey Agar	Honey Agar plus Yeast Extract (5 mg. per ml.)	Honey Agar plus Thiamine (0.5 to 1γ per ml.)	Honey Agar plus Pyridoxine (0.5 to 1γ per ml.)	Honey Agar plus Thiamine and Pyridoxine (0.5 to 1γ of each per ml.)	Polished Rice Grains	Polished Rice Grains with *B. weidmaniensis*
1	6	++++	++++	++++	++++	++++	−	++++
2	6	−	+	−	+	−	−	++
3	7	−	+	−	−	no culture	−	+
4	7	+	++++	++++	++++	++	−	++++
5	8	−	+	−	+	−	−	+
6	8	−	+	−	−	−	contaminated	++
7	8	−	++++	−	+	−	++	++
8	3½	−	+	−	−	−	−	++
9	6	−	++++	−	+	+	−	++++
10	8	−	−					
11	5	+	+					
12	4	+	++++					
13	7	−	+					
14	8	−	++					
15	8	−	++++					
16	8	−	+					
17	6	−	++					
18	6	−	++					

* No spores = −
1–5 spores = +
6–10 spores = ++
More than 10 spores = ++++.

and eight showed from one to five in a mount. The spores were typical in morphology, long, thick-walled, spindle-shaped and septate, though short and long non-septate spores were observed (FIGS. 3 and 4).

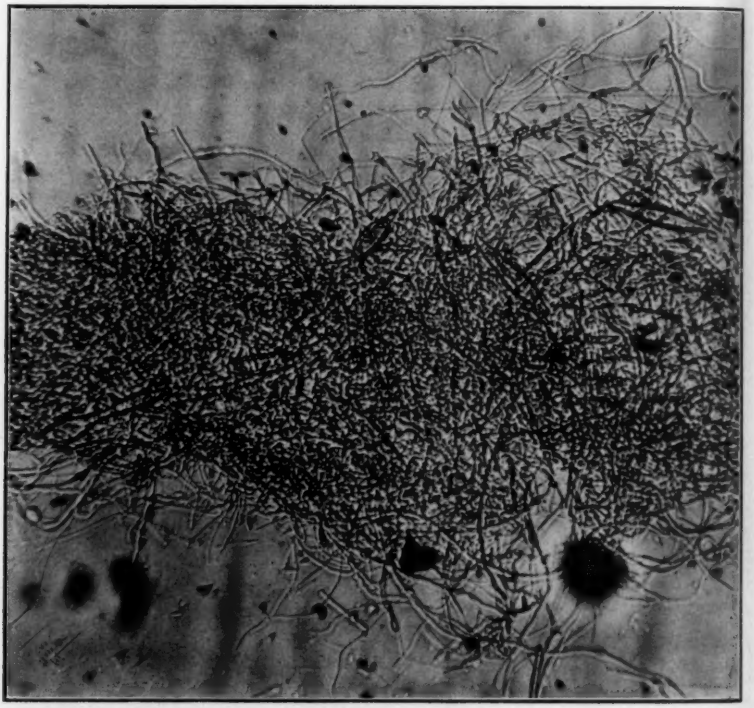

FIG. 3. Macroconidia of *Microsporum audouini* formed on honey plus yeast extract.

EFFECT OF INDIVIDUAL VITAMINS

Nine of the cultures were studied by addition to honey agar of individual vitamins of the B complex, thiamine and pyridoxine, and a combination of the two.

Macroscopic.—Thiamine was without effect except in two instances; cultures Nos. 1 and 4, which also produced macroconidia

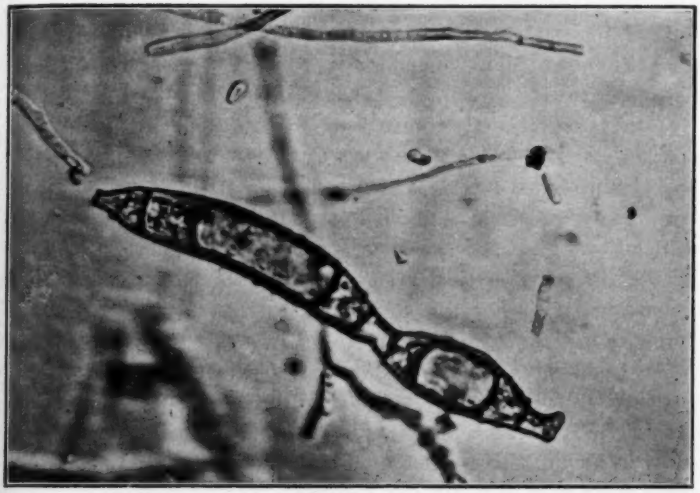

FIG. 4. Macroconidia of *Microsporum audouini* found on honey plus yeast extract greatly enlarged.

on the honey agar. Pyridoxine was somewhat more effective, macroconidia being produced in all but three of the cultures tested; these three (Nos. 3, 6 and 8) had shown a few spores on the yeast-extract agar. Strangely enough, a mixture of the two vitamins was not as effective as pyridoxine alone.

COMPARISON WITH CULTURES ON RICE GRAINS

For comparison, nine of the same cultures were grown on polished rice grains, and on rice grains infected with *B. weidmaniensis* (Table I). In one culture (No. 7) macroconidia were found on the rice grains alone. No explanation can be offered, since the culture was not one which formed macroconidia on honey agar without additional growth factors. With the addition of *B. weidmaniensis* to rice grains, all of the cultures produced macroconidia in numbers comparable to those on the yeast-extract medium. These findings support the assumption that the substances produced by the bacillus may be in the nature of vitamins.

SUMMARY AND DISCUSSION

Yeast-extract added to honey agar resulted in a marked increase in the vegetative growth of *M. audouini* and in its production of macroconidia. Its effect upon macroconidia production was comparable to that of *B. weidmaniensis*. With the substitution of pyridoxine for the yeast extract, the abundance of macroscopic growth differed little, if at all, from that on honey medium alone although an increase in macroconidia production occurred. Addition of thiamine, or thiamine and pyridoxine, did not, under the conditions studied, result in increased growth or macroconidia production.

It would appear that *M. audouini* is deficient in certain factors essential to its profuse growth and to the development of macroconidia. The routine Sabouraud's honey and dextrose agar media now in use are also apparently lacking in these nutritional factors or contain them in insufficient amounts. For many years mycologists (**2**, **4**, **5**) have recognized that these media prepared from the American or English materials were deficient in some growth substances that were present in the French products with which Sabouraud worked. Thus, as Conant (**2**) has stated, Sabouraud's excellent photographs for comparison of cultures on artificial media were of little value when it became difficult to secure comparable macroscopic pictures of the fungi.

Growth factors essential to the development of *M. audouini* are present in yeast-extract and are produced by *B. weidmaniensis*. These factors are probably identical. The indications are that the kind of peptone used in the medium to which yeast-extract is added is an important factor to maximal development of the fungus.

In order to further clarify the nature and effect of the growth-promoting factors involved here, further studies are in progress with a vitamin-free basal medium of known composition to which vitamins of the B complex will be added singly and in various combinations.

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FOMES ROBUSTUS, A HEART-ROT FUNGUS ON CACTI AND OTHER DESERT PLANTS

ROSS W. DAVIDSON AND JAMES L. MIELKE[1]

(WITH 3 FIGURES)

Heart rots are common in most trees and sometimes occur in shrubs with small woody stems, but wood-decaying Hymenomycetes have not been reported as causing decay of the woody skeleton in living cacti. In 1941 Baxter (**1**) described *Poria carnegiea* Baxter, which he collected on the woody ribs of fallen plants of the giant cactus or saguaro (*Cereus giganteus* Engelm.). He states "This plant is the first *Poria* described on cactus." In 1941, during investigations of disease and decline of the giant cactus in Arizona, L. S. Gill and P. C. Lightle of the Division of Forest Pathology observed sporophores of a *Fomes* on the bark-like tissues at the base of arms of living plants and also near the base of the main stem on ribs exposed as the result of injury.

Specimens of the *Fomes* were collected and sent to the senior author for identification and later additional collections of similar specimens from cacti and other desert shrubs and trees were obtained by the junior author and others. Also, older collections from certain woody plants filed in the Forest Pathology herbarium at Albuquerque were examined.

COMPARISON OF THE CACTUS FOMES WITH DESCRIBED SPECIES

In color of context, pore size, and spore color and size, the *Fomes* on cacti in the Southwest is similar to the larger *Fomes robustus* Karst., which is common in Europe and is known to occur occasionally in the Eastern States on oaks (**3**) and birches (**8**). Apparently it has not been reported from the Southwest unless *F. texanus* proves to be the same.

[1] Pathologists, Division of Forest Pathology, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture.

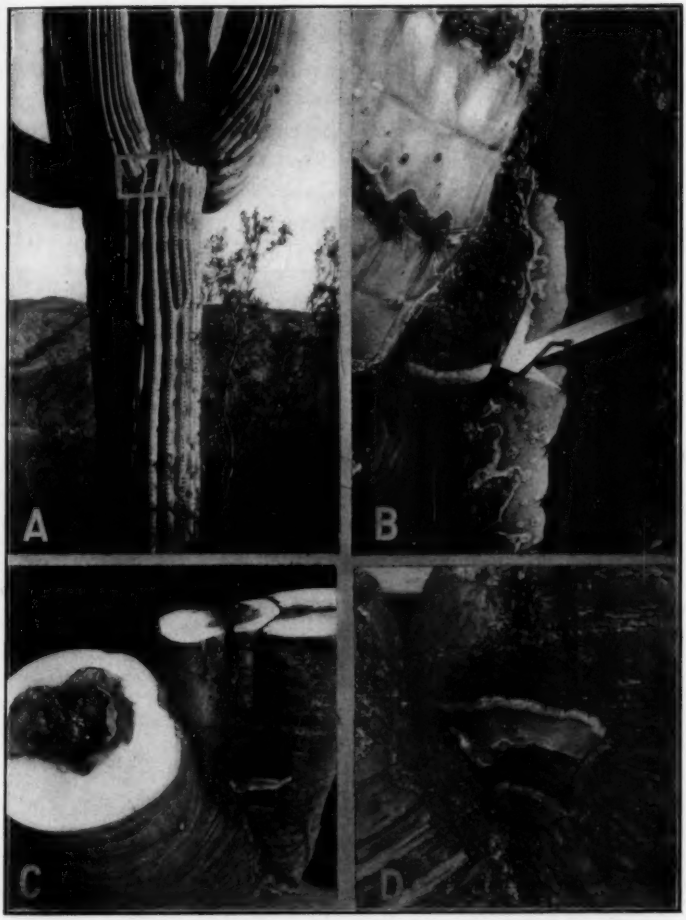

FIG. 1, *A–D; Fomes robustus: A,* Sporophore on giant cactus (*Cereus giganteus*) ; *B,* Close up of the sporophore blocked out in *A*. *C,* Sporophores on Paloverde (*Cercidium microphyllum*) and associated decay. *D,* Close up of same sporophores as shown in *C*. (Photographs *C* and *D* by Marvin H. Frost.)

The sporophores from cacti, particularly those from saguaro, were mostly small (FIG. 1, *A* & *B*, and FIG. 2, *A* & *B*) approximating in size those of *Fomes arctostaphyli* Long, which was collected on several species of *Arctostaphylos* in Arizona and described by Long in 1917 (**6**). However, the few spores observed in some of the *Fomes* specimens from cacti were larger than those of *F. arctostaphyli* and the color of the context tissue was not quite the same. The closely related species, *F. igniarius* (Fr.) Kickx., also differs in spore size, context color, and other characters.

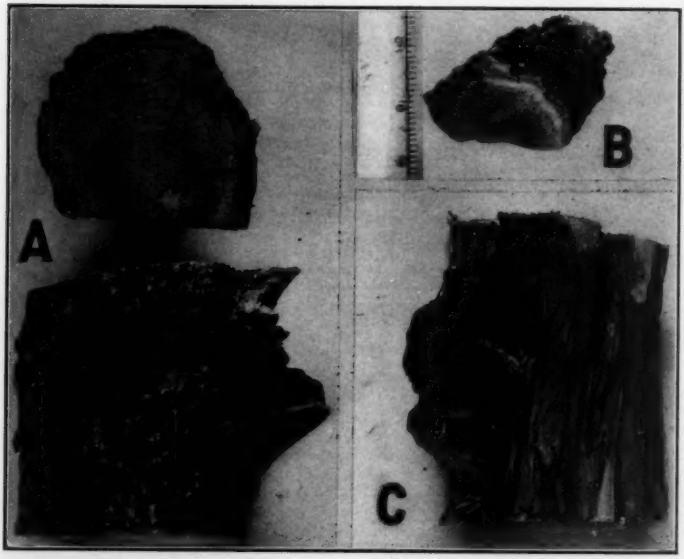

FIG. 2, *A–C; Fomes robustus: A,* Sporophore on trunk of *Opuntia versicolor; B,* Young sporophores from giant cactus; *C,* Sporophore on trunk of *Cowania stansburiana.* (*A* and *C* about ⅔ natural size.)

Complete descriptions of three species of *Fomes* on *Juniperus* spp. in the Southwest are given by Hedgcock and Long (**4**). Of these *F. juniperinus* (Schrenk) Sacc. & Syd. is very different in context color, and *F. earlei* (Murr.) Sacc. & D. Sacc. has spores more nearly the same size as the cactus fungus but the pores are much larger. *F. texanus* (Murr.) Hedgc. & Long, the other species, is

similar in general color and pore size but the spores are recorded as smaller (3–4 μ) by Murrill (**7**), and Hedgcock and Long (**4**). However, the latter state that spores are rarely found, and it seems doubtful that the size as given by them is correct. Lloyd (**5**) states that spores are 5–6 μ and not as described.

The only other similar species known to occur in the Southwest is one that has been collected on the woody legumes *Prosopis* spp. and *Acacia* spp. It has smaller dark brown spores and has been referred to the species *Fomes rimosus* (Berk.) Cke. (**5**).

PURE CULTURE STUDIES

Cultures were obtained from fresh sporophores of the *Fomes* on cacti (FIG. 3, *A–E*) and from other of the small forms from the Southwest to aid in identifying the species. These included, in addition to the cactus form, cultures from *F. rimosus*-like sporophores collected on *Prosopis* and *Acacia*, and from *Fomes arctostaphyli* and *F. texanus* (FIG. 3, *F–I*). Cultures of most of the other common species of *Fomes* were available in the stock culture collection of the Division of Forest Pathology at Beltsville, Md. (**2**, **3**).

A comparison of cultures shows that *Fomes arctostaphyli* and *F. igniarius* are distinct species and that both are quite different from the cactus *Fomes*. *F. rimosus* from the Southwest is in general similar to the eastern *F. rimosus* that is so common on *Robinia pseudoacacia* L., but a more careful comparison might reveal some consistent minor differences. Growth rate of the *Prosopis* fungus is about the same as that of the *Fomes* on cacti but mat color and texture are different.

The one available culture of *Fomes texanus*, the species that appears to be the most closely related of the Southwest forms, was similar in color and texture of mat to the cactus fungus but grew much more slowly (FIG. 1,*F*). In general the cactus fungus was very similar in growth characteristics to eastern cultures of *F. robustus* from oaks. Cultures of *F. robustus* have been described and illustrated by Campbell (**2**) and by Davidson, Campbell, and Vaughn (**3**).

The study of cultures further revealed that all isolates from

sporophores on cacti were somewhat similar culturally although there was some variation in growth rate and mat texture. Also, cultures from *Fomes* sporophores collected on several species of living shrubs and trees were more like those from cacti. These other hosts are listed later following the description of the fungus.

TYPE OF DECAY AND HOST RELATIONSHIP

All of the species of *Fomes* mentioned in the foregoing account are known to sporulate on and cause heart rots of living trees and shrubs. Also, they all cause rots of a white, yellowish, or tan color, depending upon the host. In no case is the rot of the brown carbonizing type. On the shrubs and trees the sporophores develop either at dead branch stubs or are associated with injuries of one kind or another that expose the heartwood. No evidence has been found indicating that any of the forms from the Southwest attack outer sapwood around the point of infection. However, in the Eastern States *F. robustus* has frequently been collected on rather restricted dead areas or cankers and is therefore believed to be somewhat pathogenic.

The *Fomes* on giant cactus is most commonly found on the hard, bark-like outer tissues at arm bases and occasionally occurs near the base of the main stem on woody ribs exposed as the result of injury. On chollas (*Opuntia* spp.) (FIG. 2, *C*) the sporophores develop on the main stem generally near ground level but occasionally they are found as high as eighteen inches above it. They occur at branch stubs or on injured areas where the woody skeleton is exposed. Decay is sometimes found extending upwards well into the branches or to a height of four feet or more.

Those saguaros that were broken off near ground level during wind storms were found to have their basal ribs badly rotted by the *Fomes*. Also, the fungus was isolated from ribs in the basal portion of arms that had fallen from living plants. In chollas the *Fomes* rots the woody skeleton near the base of the plants, impairing their mechanical support and causing them to fall over eventually and die.

Sporophores on cacti and several other hosts are similar to *F. robustus* but are much smaller, particularly on giant cactus, than re-

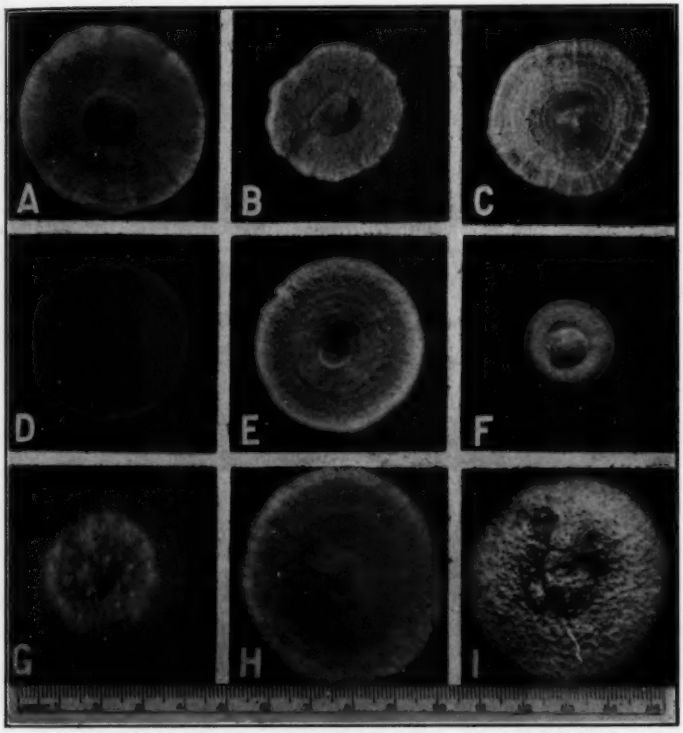

FIG. 3, *A–I;* Cultures of *Fomes* spp. from southwest desert plants. *A–E, Fomes robustus: A* and *B,* from *Cereus giganteus; C,* from *Opuntia fulgida; D,* from *Cowania stansburiana; E,* from *Canotia holacantha; F, Fomes texanus* from *Juniperus scopulorum; G* and *H, Fomes rimosus* from *Prosopis juliflora* and *Acacia greggii; I, Fomes arctostaphyli* from *Arctostaphylos* sp.

corded specimens of that species and the surface of sporophores is more rimose (FIG. 2, *A–D*). It is here considered as *F. robustus* or a closely related form of that species and the following description gives the outstanding characteristics of the fungus as it occurs in the Southwest:

Sporophores small, 1.5–10 cm. wide by 1–10 cm. by 1–7 cm. deep, hard, no crust, smooth when young, becoming strongly rimose, gray-black, margin smooth to velvety, yellow brown, context yel-

low brown, tubes stratose; pores 4–6 per mm., round; spores globose, hyaline to yellowish, 7–8 μ diameter.

It was especially common on living cacti and occasionally found on other living desert shrubs and small trees as follows:

Cereus giganteus F. P. No. 89760, collected Saguaro National Monument, Tucson, Arizona, July 17, 1941 by P. C. Lightle and L. S. Gill, No. 89669 coll. Saguaro National Monument Jan.–Feb., 1943 by J. W. Kimmey and J. L. Mielke, and No. 89670 coll. Saguaro Nat. Mon., Jan. 19, 1943 by Kimmey and Mielke; *Opuntia arbuscula* Engelm., No. 89673 coll. Saguaro Nat. Mon., Jan.–Feb., 1943 by Mielke and Kimmey; *Opuntia fulgida* Engelm., No. 89674 coll. Saguaro Nat. Mon., Jan. 18, 1943 by Kimmey and Mielke, and No. 66245, coll. Saguaro Nat. Mon., Apr. 24, 1943 by Mielke; *Opuntia versicolor* Engelm., No. 89757 coll. by P. C. Lightle, Saguaro Nat. Mon., May 1, 1941, and No. 89672, coll. Saguaro Nat. Mon., Jan.–Feb., 1943 by Mielke and Kimmey: *Canotia holacantha* Torr., No. 33338 coll. Estrella Mts., Maricopa Co., Arizona, Nov. 28, 1920 by L. N. Goodding, and No. 89279 coll. Tonto National Forest, Arizona, Oct. 20, 1938 by L. S. Gill and H. S. Palmer; *Cercidium microphyllum* (Torr.) Rose and Johnst., No. 89668 and No. 94250 coll. Saguaro Nat. Mon., Feb., 1943 by Mielke and Kimmey, and May, 1943 by Mielke; *Cowania stansburiana* Torr., No. 89665, coll. Camille Hills, Santa Cruz Co., Arizona, Jan. 20, 1943 by L. N. Goodding; *Vauquelinia californica* (Torr.) Sarg., No. 68946, coll. Jacumba, California, Jan. 1, 1929 by L. N. Goodding and S. B. Detwiler; *Larrea tridentata* (DC.) Coville, No. 89759 coll. Saguaro Nat. Mon., May 3, 1944 by Mielke.

SUMMARY

Sporophores of a small *Fomes* sp. from living giant cactus (*Cereus giganteus*) and some large, living chollas (*Opuntia* spp.) were studied and compared with *Fomes* sporophores from several other woody plants in the dry areas of southwestern United States. From morphological and cultural characters it was found to be closely related to *Fomes robustus* Karst., although sporophores were smaller and more rimose.

Sporophores from several associated desert shrubs and small trees other than cacti were found to be the same fungus. *Fomes texanus* from *Juniperus* is morphologically very similar to *F. robustus* but differs culturally from this form in its slower growth. *F. arctostaphyli,* which is another small species in the West, differs culturally and morphologically from *F. robustus* and is also culturally distinct from the large and somewhat closely related species *F. igniarius.*

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A NEW PHYTOPHTHORA CAUSING ROOT AND COLLAR ROT OF CINCHONA IN PERU [1]

BOWEN S. CRANDALL [2]

In the course of investigations on the root and collar rot of cinchona in Peru (3) a *Phytophthora* was isolated consistently from the advancing margins of decay lesions in the basal portions of the roots and in the collar of plantation age trees and occasionally from all parts of the stem of nursery age seedlings and transplants.

There are practically no published accounts of cinchona root disease in the Western Hemisphere, but from the Asiatic regions the investigator is almost overwhelmed by the amount of material published on root diseases of cinchona. However, only recently and in but few instances has *Phytophthora* been described as the cause. Coster (2) in 1940 reported an undesignated species of *Phytophthora* associated with cinchona stripe canker in Java. Also in 1940 Thompson (6) reported *P. cinnamomi* Rands causing cinchona root rot in British Malaya. In 1936 Sawada (9) described a new species, *P. cinchonae* Saw., which he considered to be the cause of a top dieback. This dieback differed from other described dieback diseases of cinchona in that the infection court was apparently in the stem, with the fungus subsequently spreading upward to infect the top. Celino (1)[3] and Kheswalla (8), in reporting *P. palmivora* Butler as the cause of seedling

[1] The investigations reported here are made possible by funds provided through the U. S. Inter-Departmental Committee for cooperation with the American Republics, together with the financial support of the Government of Peru.

[2] Pathologist, Office of Foreign Agricultural Relations, U. S. Department of Agriculture, and Chief, Department of Plant Pathology and Entomology, Estación Experimental Agricola de Tingo María, Peru, S. A. In cooperation with the Division of Forest Pathology, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture.

[3] Published as *P. faberi* Maubl., a synonym of *P. palmivora* (11).

blights, and Crandall and Davis (**4**), in reporting *P. parasitica* Dast. as the cause of wilt and stem canker of cinchona, state that the infection took place in the tender tissue of the growing tip. In the work on the wilt and stem canker previously mentioned (**4**) and on this root and collar rot, *P. parasitica* and the *Phytophthora* described here commonly are found in the same plant. *P. parasitica* often spreads downward almost to the collar, especially in cortical tissue, whereas the new root-rot *Phytophthora* has often been isolated from tissue four to five inches up the stem in the case of *Cinchona pubescens* Vahl and to a height of eight inches in streak infections. In many cases involving nursery age plants, the new *Phytophthora* was found throughout the stem tissue and symptoms typical of top dieback were present. Although *P. cinchonae* does not appear to be closely related either to the *Phytophthora* described here or to the more closely related root-disease-producing *Phytophthora,* its description has been compared along with the others.

No description has been found in the literature of a *Phytophthora* resembling that of the one isolated from the root and collar rot of cinchona and it is here described as a new species. The specific name is derived from the Spanish word for the cinchona tree, which was adapted from the original Quechua Quina-quina. Two of the alkaloids extracted from the cinchona bark, quinine and quinidine, received their names from the same source.

Little cultural or morphological variation between isolates from the two known locations of the disease in Peru has been observed. Such variations as occur are no greater than those between isolates from the same locality. For this reason, measurements in the description that follows are based on an isolate from the point of original discovery of the disease, Fundo Sinchono. This isolate, No. C–67 of the culture collection of the Department of Plant Pathology and Entomology of the Estación Experimental Agricola de Tingo María, is virulently pathogenic and was isolated from a case of root and collar rot in a plantation tree. Sporangia and zoospores were produced in abundance forty-eight hours after mycelia in blocks of ten-day-old oatmeal agar cultures were placed in running brook water. None were produced on solid media or when plates were flooded or when agar blocks with mycelium were

placed in distilled water or liquid media. Oogonia and oospores were produced with regularity, although not abundantly, in old oatmeal agar cultures. The prolific production of chlamydospores by this species makes it extremely difficult to locate oogonia.

Phytophthora Quininea n. sp.[4]

Hyphae primum continuae, maturae sparse septatae, 3.7–8 μ in diam.; sporangia in aqua fluenti rivi abunde producta, non-papillata, ovata usque obpyriformia, 45.9–67.5 × 25.5–37.5 μ (media 53.8 × 31.1 μ), rare e tubulis, plerumque e 14–20 zoosporis globosis 8–10 μ in diam. in aqua germinantia; sporangiophora in diam. minoria quam hyphae gerentes, apicem versus subattenuata, simplicia, usque 75 μ longa, sporangia singula terminalia gerentia, deinde basim sporangii evacuati penetrantia et sporangia nova gerentia; chlamydosporae terminales et intercalares, brunneae, sphaericae, 45–90 μ; vesiculae abundantes, in forma et magnitudine irregulares; oogonia subsphaerica usque sphaerica, hyalina vel pallide flavidula, levia, 67.5–82.5 μ; oosporae globosae, hyalinae vel pallide flavidulae, granulosae, 48.7–63.7 μ; antheridia paragyna, in forma et magnitudine variabilia.

Hab. in radicibus et collaribus *Cinchonae officinalis* et *C. pubescentis*, Peru.

Hyphal growth similar to that of other Phytophthoras, continuous when young, becoming sparsely septate with age, 3.7–8.0 μ, mostly approaching 8.0 μ, in diameter; vegetative growth luxuriant and cottonlike on oatmeal agar, aerial hyphae scarce and cobweblike on cornmeal and potato dextrose agars, deep growing on and in the media, granular in appearance because of the early production of chlamydospores and vesicles; sporangia not observed on solid media but produced abundantly in running brook water, nonpapillate, ovate to obpyriform, widest near the base, 45.9–67.5 × 25.5–37.5 μ (average of 30 mature sporangia 53.8 × 31.1 μ), germinating in water, rarely by germ tubes, regularly by discharge of 14–20 globose to ellipsoidal zoospores, 8–10 μ in diameter; sporangiophores smaller in diameter than the hyphae from which they arise but within limits of hyphal size, tapering slightly toward the tip, simple, undifferentiated, up to 75 μ long, with single terminal sporangia, resuming growth through the base of the evacuated sporangium and producing new sporangia within or beyond the empty one; terminal and intercalary dark brown, spherical chlamydospores, 45–90 μ, produced abundantly after 132 hours on cornmeal and oatmeal agars; vesicles abundant and irregular in size and shape, giving a thickened appearance to the hyphae and caus-

[4] Latin description prepared by Miss Edith K. Cash, Associate Mycologist, Division of Mycology and Disease Survey, Bureau of Plant Industry, Soils, and Agricultural Engineering.

ing irregular growth; oogonia subspherical to spherical, hyaline to faint yellow, smooth, 67.5–82.5 μ; oospores spherical, hyaline to faint yellow, granular, 48.7–63.7 μ; antheridia paragynous, irregular in shape, variable in size; in the host mycelium penetrating inner bark, phloem, cambium, and outermost wood layers, inter- and intra-cellular. Causing a destructive root and collar rot of Ledger form *Cinchona officinalis* L. and *C. pubescens* Vahl in Peru.

Phytophthora quininea is a member of the group containing *P. cinnamomi, P. erythroseptica* Pethyb., *P. cambivora* (Petri) Buis., *P. cryptogea* Pethyb. & Laff., *P. richardiae* Buis., *P. drechsleri* Tucker,[5] *P. megasperma* Drechsl. (**6**), and *P. fragariae* Hickman (**7**). Morphologically it resembles *P. cambivora* and *P. cinnamomi* in the production of chlamydospore-like vesicles, differs from *P. cinnamomi* specifically in the absence of the grapelike clusters of chlamydospores or chlamydospore-like bodies, and differs from all in this group excepting *P. megasperma* by the production of large oogonia with paragynous antheridia. *P. quininea* differs from *P. megasperma* by its larger oogonia and from it and the others in this group by the abundant production of large, true chlamydospores. *P. quininea* differs from *P. cinchonae* morphologically in that *P. cinchonae* is described as having sporangia with flattened papillae and of smaller size (18–68 × 13–38 μ, average 41.2 × 23.0 μ), produced both terminally and laterally on short sporangiophores (24–41 μ). No chlamydospores or oogonia are reported for *P. cinchonae*. Sawada's figure (**9**) of *P. cinchonae* shows non-papillate sporangia resuming growth through the evacuated sporangia, characteristic of the root-rot *Phytophthora* group. *P. cinchonae* has a lower minimum growth temperature (10° C.) and a higher optimum temperature (30° C.) than *P. quininea*.

P. quininea makes its optimum growth on cornmeal agar at pH 6.0. At this pH growth is regular. At pH 7.0 and 5.5 growth becomes irregular because of the production of vesicles. Almost no growth occurs at pH 8.5. When grown on cornmeal agar at pH 6.0 the optimum temperature for growth is 25° C. Growth occurred between 15° and 30° C. on cornmeal agar. At the opti-

[5] For the preceding six species the descriptions as reviewed by Tucker (**11**) are used, together with additional information from the author's work with *P. cambivora* and *P. cinnamomi* (**5**).

mum temperature of 25° C., *P. quininea* grew radially at the rate of 8 mm. per 24 hours.

P. quininea causes a disease of the root and collar tissue of Ledger form *C. officinalis* plantation trees and of nursery stock of this species and of *C. pubescens*.[6] The disease first manifests itself in the aboveground portions of the tree by the loss of the normal green color, giving the leaves a reddish appearance. This symptom is shortly followed by wilting and loss of all but the small terminal leaves prior to death. In the collar region an external swelling usually is present immediately above the invaded tissue. The fungus progresses into healthy tissue and produces internally reddish-brown wedge-shaped areas. The pathogenicity of *P. quininea* has been proved by inoculation on Ledger form *C. officinalis* and *C. pubescens* trees. In addition it has been found by inoculation that *C. officinalis*[7] from the Tambopata Valley of Peru and from Bolivia, and *C. micrantha* Ruiz & Pavon of Peru are susceptible to the disease.

The disease caused by *P. quininea* is known only at two localities in the upper Ucayali River basin in Peru: Hacienda Punizas, near La Merced on the Perene River, Department of Junin; and Fundo Sinchono, 60 km. east from Tingo María on the Tingo María-Pucallpa highway, on the upper headwaters of the Aguaytia River, Department of Loreto.

ESTACIÓN EXPERIMENTAL AGRICOLA
DE TINGO MARÍA,
PERU, S. A.

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LAGENIDIUM HUMANUM, A SAPROPHYTE ISOLATED ON DEAD HUMAN SKIN

JOHN S. KARLING

(WITH 39 FIGURES)

In the course of a study of saprophytic chytrids which inhabit keratinized tissues of animals the author discovered a large species of *Lagenidium* on small pieces of dead human skin. Bits of this tissue had been added to a watered soil culture from a cemetery near Briarcliff, N.Y. as a substratum for isolating and growing *Rhizophydium keratinophilum* (**3**) and *Phlyctorhiza variabilis* (**4**). Within three days it became heavily infected with *Lagenidium* sp. and the last of the two keratinophilic chytrids mentioned above. This species of *Lagenidium* was subsequently isolated and grown in pure culture on agar containing minute amounts of peptone, dextrose and yeast extract. Therefore, it is not strictly keratinophilic although it has been found only in keratinized tissues in nature. It also grows fairly rapidly and produces large submerged colonies in a liquid medium containing 0.1 per cent peptone, 1.0 per cent dextrose and 0.1 per cent yeast extract. Further studies are now under way to determine more specifically its nutrient requirements and growth by dry weight.

The genus *Lagenidium* includes approximately twenty species (**5**, **6**) some of which are imperfectly known, doubtful, and probably synonymous. All are reported to be weakly or strongly parasitic in algae, rhizoids of mosses, pollen grains, rotifers, mosquito larvae, copepods, *Daphne*, and eggs and newly-hatched individuals of the common blue crab. Only one species, *L. giganteum*, has been isolated and grown in pure culture on synthetic media. Couch (**1**) reported that this species may be cultured as a saprophyte but is weakly parasitic on mosquito larvae, *Daphne* and copepods in nature. The species discovered by the author on dead human skin is, therefore, the first member of *Lagenidium* reported to occur saprophytically in nature. It is characterized by

a coarse, extensive, richly-branched, septate mycelium, reniform zoospores, and sexually-formed oospores. Thus, its thallus is quite different from that of most species but resembles the coarse mycelium of *L. giganteum* and *L. Callinectis* Couch (2). It differs, however, from these two species by smaller zoospores and sexually-formed oospores. Accordingly, it is interpreted as a new species and named *L. humanum.**

Lagenidium humanum sp. nov. (FIGS. 1–39)

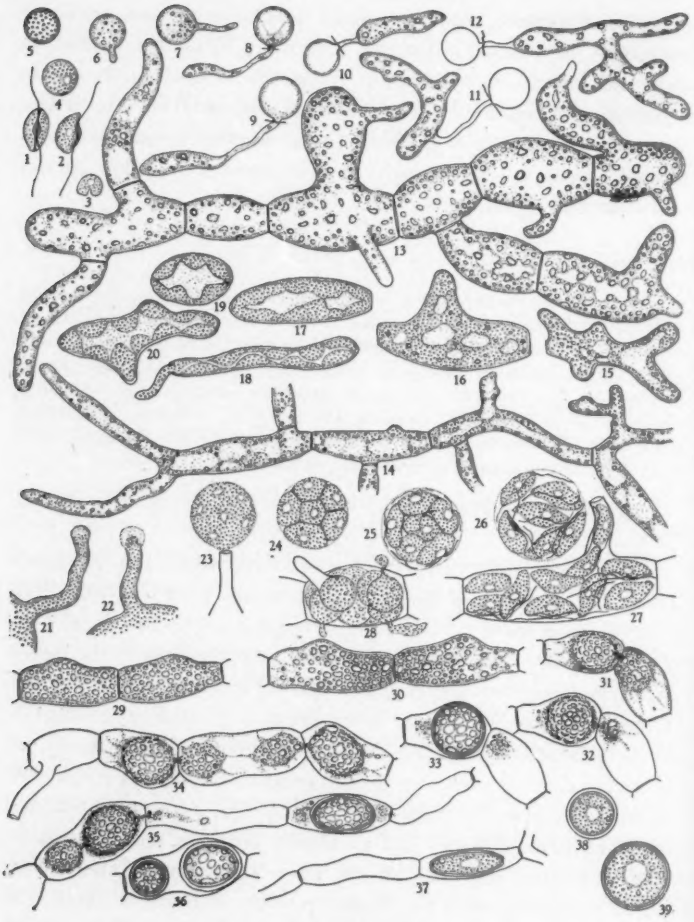
Fungus saprophyticus; thallis multicellulosis, tenuibus, ramosis, septatis, 4–20 μ diam.; sporangiis elongatis (4–7 × 15–200 μ), subsphaericis (15–30 μ), ovalibus (10–15 × 18–30 μ), oblongatis, lobatis, irregularibus vel tenuibus in unum tubulos exentibus; zoosporis reniformibus (3.5–4.5 × 7.5–8 μ); cystosporiis sphaericis (6–7.5 μ); oogonis et antheridiis elongatis (5–7 × 15–22 μ), ovalibus (10–15 × 18–25 μ), subsphaericis (10–25 μ), tenuibus, fusiformibus vel lobatis; oosporis hyalinis, laevibus, sphaericis (10–18 μ), ovalibus (8–12 × 14–17 μ) vel oblongatis; germinatione ignota.

Saprophytic in dead human skin and various synthetic media, Briarcliff, N. Y.

The zoospores of this species are reniform with a ventral groove (FIGS. 1, 2, 3) in which the two flagella appear to be inserted. The protoplasm is more or less evenly granular in appearance and includes a small oval or spherical vacuole. At the close of the motile period the zoospores round up and become cystospores (FIGS. 4, 5). These germinate within two hours (FIGS. 6, 7) without giving rise to secondary zoospores, so that *L. humanum* is monoplanetic as far as is known at present. As the germ tube elongates in the substratum, its apex enlarges (FIGS. 8, 9, 10), becomes lobed and branched (FIGS. 11, 12) and eventually develops into the thallus. The cystospore and part of the germ tube remain attached as empty structures until the thallus is well established. Thus, the vegetative development of *L. humanum* is fundamentally similar to that of other filamentous species of *Lagenidium*.

The mature thallus varies so greatly in length and diameter that it is difficult to give representative measurements and almost impossible to use vegetative characteristics for diagnostic purposes. In rare and exceptional cases it may be reduced to one cell, as in

* The author is very grateful to Dr. Theodor Just of Notre Dame University for the name and Latin diagnosis of this species.



FIGS. 1–39. *Lagenidium humanum.*

Olpidium, whereas in most instances it is greatly extended, branched, and mycelioid like species of *Pythium*. On dead skin it is frequently composed of relatively short, oval, truncate, lobed or branched segments and is constricted at the septa as shown in fig. 13. Such thalli are often friable or fragile so that in mounting them

for microscopic study the segments separate as individual cells at the septa (FIGS. 15–20). These cells may vesiculate slightly as they continue to mature, and in most cases they eventually form zoospores if conditions are favorable. On 0.5 per cent agar and in liquid media, on the other hand, the thallus is usually more filamentous with longer and narrower segments, as shown in fig. 14. Like that of other species of *Lagenidium*, the protoplasm has a pale grayish or whitish gleam and contains numerous vacuoles and bodies (FIGS. 13, 14). These bodies vary greatly in size from spherical, oval, oblong, elongate to angular in shape, but they are not as sharply refractive as the globules which occur in most chytrids.

Each segment of the sporangium is capable of becoming a sporangium and producing zoospores, but in this process they do not undergo any marked structural differentiation except the formation of an exit tube. In preparation for sporogenesis the protoplasm of the incipient sporangium undergoes the usual and well-recognized changes in appearance. The bodies begin to break up and become smaller, and the material of which they are composed becomes more highly dispersed (FIG. 15). As a result the protoplasm as a whole takes on a more uniformly grayish-granular appearance (FIG. 16). At the same time the vacuoles and their tonoplasts become more clearly-defined and conspicuous and eventually coalesce (FIG. 17) to form a large vacuole (FIGS. 18, 19, 20). By this time the exit tube has formed (FIG. 18), and it may be papillate (FIG. 20) or greatly elongate or filamentous. At this stage the tonoplast of the vacuole is usually scalloped in contour (FIG. 20), so that the sporeplasm looks as if it were undergoing centripetal cleavage. Apparently, these are not cleavage furrows, or if they are, cleavage is not completed at this stage because it usually occurs outside the sporangium.

In preparation for discharge of the sporeplasm the tip of the exit tube becomes slightly inflated (FIG. 21), deliquesces, and a globular mass of hyaline substance emerges (FIG. 22). The granular sporeplasm pushes up into this mass and expands it to the extent that it eventually consists only of a thin hyaline surrounding layer. This layer is probably transformed into the hyaline membrane which later may be seen around the zoospores (FIGS. 25, 26). The subsequent cleavage and maturation stages of the zoospores are

identical to those described so well by Couch (1) for *L. giganteum* with the exception that the central vacuole is not very conspicuous (FIGS. 23, 24). If dehiscence is delayed, cleavage may occur within the sporangium (FIG. 27), so that the zoospores emerge fully formed. In rare cases the exit tube fails to deliquesce, with the result that cleavage and swarming of the zoospores may occur within the sporangium. In such instances the zoospores come to rest and form cystospores which may germinate *in situ* within two hours (FIG. 28).

The so-called oospores of *L. humanum* are formed sexually by fusion of the protoplasts of adjacent cells in the thallus. So far as is known any segment of the thallus may become an oögonium or antheridium, and these gametangia are not structurally differentiated as such. It is particularly noteworthy that the difference in size and shape exhibited by them appears to be fortuitous. The antheridium may be slightly larger than the oögonium (FIG. 37) or vice versa (FIG. 35) or they may be of similar size and shape (FIGS. 29, 30), depending on which of the segments in the thallus function as gametangia. Therefore, in the initial stages it is impossible to determine which is the antheridium or oögonium (FIG. 29). It is only after the protoplasm of one cell begins to move into the other that they may be recognized. Accordingly, recognition of the antheridium in this species is based solely on the movement of its protoplasm and not on distinctive structural characteristics. Thus, sexual reproduction in *L. humanum* may be described as isogamous or heterogamous, depending on the accidental size and shape of the respective gametangia.

Segments which are to become gametangia usually contain denser protoplasm and more bodies (FIG. 29) than ordinary vegetative cells. The first visible change in preparation for plasmogamy is a contraction of the protoplasts toward the intervening septum (FIG. 30) in much the same manner as described by the author (6) for *L. microsporum*. Some of the bodies or globules appear to coalesce, because they become larger in size and smaller in number as contraction progresses. At the same time a pore is formed in the septum, and the protoplasm of the antheridium begins to flow into the oögonium (FIGS. 31, 32). After this process has been completed the zygote rounds up and becomes enveloped by a thick,

hyaline wall (FIG. 33). In a few cases observed a small part of the protoplasm of both gametangia was left behind or excluded from the zygote (FIGS. 33, 35A). Whether or not this is extraneous material resulting from a slight differentiation of gametes, and is to be interpreted as periplasm is not certain. The answer to this question must await further cytological study of fixed, sectioned and stained material.

Variations of the usual process of plasmogamy may occur in this species. In one case observed the protoplasm of a large antheridium lying between two oögonia constricted into two portions (FIG. 34), each of which later flowed into the adjacent oögonia. Thus, one antheridium is capable of fertilizing two oögonia as in species of *Olpidiopsis*. In another instance the oöplasm divided into two unequal parts (FIG. 35) during plasmogamy and eventually produced two oöspores (FIG. 39). Inasmuch as division occured before plasmogamy was completed it is not improbable that the smaller oospore is monoploid.

As the oöspores mature the globular bodies begin to break up and disperse, so that the protoplasm becomes more evenly granular (FIGS. 37–39). The oögonium wall disintegrates after a few weeks and liberates the oöspores. So far germination of the oöspores has not been observed.

SUMMARY

Lagenidium humanum was isolated on bits of dead human skin which had been floated on a watered soil sample collected in a cemetery at Briarcliff, N. Y. It was subsequently isolated from this substratum and grown in pure culture on agar and in nutrient liquid media. This species is characterized by a coarse, filamentous, mycelioid, branched and septate thallus, reniform zoospores, and sexually-formed oospores. The antheridia may be slightly larger than the oögonia or vice versa, or the two gametangia may be similar in size and shape. Accordingly, sexual reproduction in *L. humanum* may be isogamous or heterogamous.

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DESCRIPTION OF FIGURES

FIGS. 1–39. *Lagenidium humanum*. FIGS. 1, 2, 3. Zoospores in ventral, side and median cross section views, respectively, × 1100. FIGS. 4, 5. Cystospores, × 1200. FIGS. 6, 7. Germination of cystospores on agar, × 1300. FIGS. 8, 9. Successive stages of germination of cystospores on and the enlargement of the germ tube in dead human skin, × 1300. FIGS. 10, 11, 12. Later stages of development of the thallus from the end of the germ tube; cystospore and part of germ tube persistent, × 1300. FIG. 13. Broad, septate, branched type of thallus from dead human skin, × 1100. FIG. 14. Filamentous, narrow thallus from 0.5% agar medium, × 1100. FIGS. 15–19. Successive maturation stages of separated segments into zoosporangia, × 1100. FIGS. 21, 22. Inflation and deliquescence of tip of exit tube, respectively, × 1200. FIG. 23. Naked, discharged mass of sporeplasm, × 1200. FIGS. 24, 25, 26. Cleavage and maturation stages of zoospores in a vesicle, × 1300. FIG. 27. Late dehisced sporangium with zoospores, × 1300. FIG. 28. Sporangium which failed to dehisce, cystospores germinating *in situ*, × 1300. FIG. 29. Antheridium and oogonium of similar size and shape, × 1100. FIG. 30. Late stage of same gametangia, contents contracting towards intervening septum, globules coalescing, × 1100. FIGS. 31, 32. Successive stages of isogamous plasmogamy, × 1100. FIG. 33. Same gametangia after completion of plasmogamy and formation of oospore; remnants of protoplasm in both gametangia, × 1100. FIG. 34. Large central antheridium whose content has divided into two portions, which are flowing into adjacent oogonia, × 1100. FIG. 35. Heterogamous plasmogamy; ooplasm dividing into two unequal portions during fusion, × 1100. FIG. 36. Same oogonium later with two oospores, × 1100. FIG. 37. Elongate oospore in narrow oogonium; antheridium larger than oogonium, × 1100. FIGS. 38, 39. Mature spherical oospores, × 1200.

SOME NOTEWORTHY RUSTS—II

M. J. THIRUMALACHAR

(WITH 18 FIGURES)

HEMILEIA WRIGHTIAE Racib. Paras. Alg. und Pilz. Javas, I, p. 26–27. 1900.

Hemileia Wrightiae, first described from Java by Raciborski as *Hemileiopsis Wrightiae,* has been found to occur in abundance on the leaves of *Wrightia tinctora* near Bangalore, South India. The rust is hypophyllous and can be collected in large quantities in the months of February and March. Stevens (**1932**), who recorded the rust in the Philippines on *Wrightia Laniti,* described what he considered to be the aecial stage of the rust, and, incidentally, for the genus *Hemileia,* for the first time. The aecia, according to him, are uredinoid, the sori appearing bright reddish in color. The aeciospores resemble the urediospores except that they possess smaller aculeate processes and that on germination they produce unbranched germ tubes. No pycnia were seen to accompany such uredinoid aecia.

In the material of the same rust collected by the writer near Bangalore on *Wrightia tinctora* large numbers of telia with viable teliospores were present and hence opportunity was taken to carry out sporidial inoculations to confirm the reported occurrence of the aecial stage of the rust by Stevens. Clusters of teliospores were easily separated with a needle from the mass of urediospores on slides under the microscope. The teliospores thus separated were used for inoculating young leaves of *Wrightia tinctora.* The inoculated plants were inclosed in moist chambers for 48 hours after which they were transferred to the greenhouse for observation. The teliospores readily germinate within five hours, developing numerous sporidia. No signs of infection appeared, even after a lapse of twenty days, and all inoculation experiments have given negative results. This supports the view that *H. Wrightiae* is not an autoecious rust with an aecial stage on the same host, as

considered by Stevens. The spore form described by Stevens as aecia might be only uredia.

Hemileia mysorensis Thirumalachar & Gopalakrishnan sp. nov.

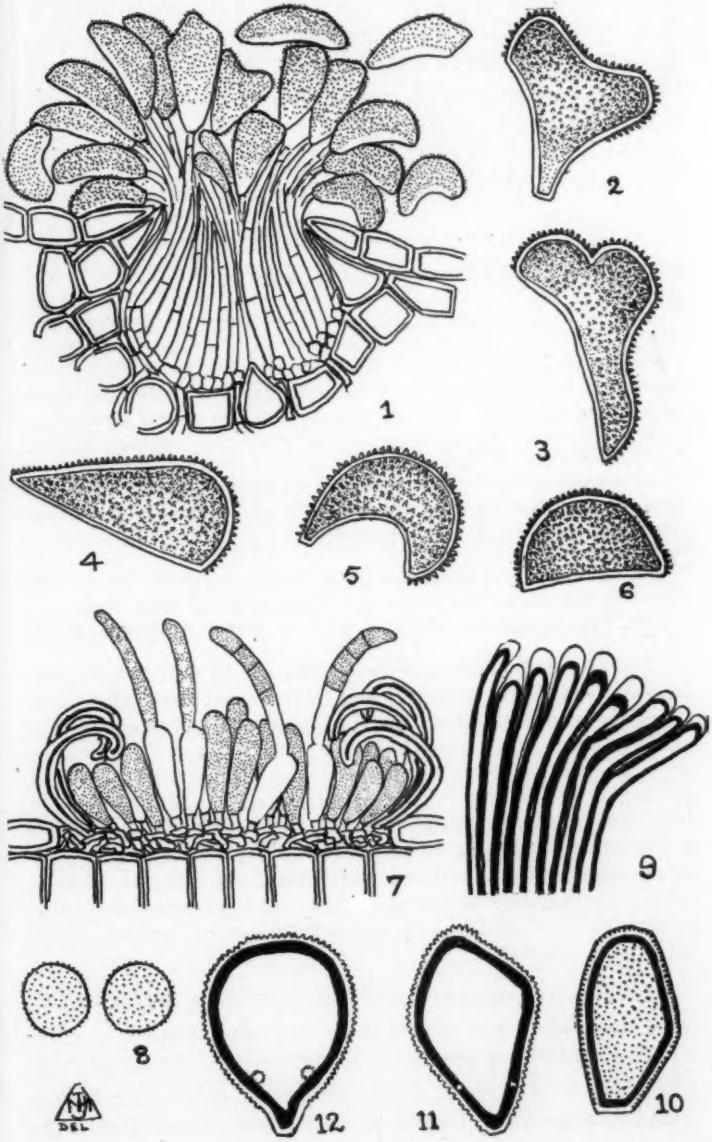
Infectionis maculae indistinctae. Uredia minuta, hypophylla, raro amphigena, sparsissima, citreo-lutea, pulverulenta. Sori superstomales, constantes ex massa hypharum fasciculatarum quae bene evolvuntur in substomali spatio, sed in sporas non mutantur quaeque ex stomate emergunt atque acervatas sporas producunt sporogenis sporophoris insidentes. Urediosporae bilateraliter symmetricae, citreo-luteae, triangulares vel reniformes 30–45 × 19–25 μ, in superficie convexa acutatis processibus opertae leves in superficie plana.

Hab. in foliis *Gymnema* sp. indet. (Asclepiadaceae), Balehonnur, Mysore, South India, leg. K. S. Gopalakrishnan, 12–4–1946. Typus positus in Herb. Crypt. Ind. Orient., New Delhi, in Arthur Herb., Purdue Univ., Lafayette, Indiana, U. S. A., in Herb. I. M. I., Kew, in Anglia.

Infection spots indistinct. Uredia minute, hypophyllous, rarely amphigenous, very sparse, orange-yellow, pulverulent; sori superstomal, composed of a well developed mass of fasciculate hyphae in the substomal space without getting transformed into spores, emerging out of the stoma and bearing clusters of spores on sporogenous sporophores. Urediospores bilaterally symmetrical, orange-yellow, triangular to reniform in shape, 30–45 × 19–25 μ, covered with aculeate processes on the convex surface and smooth on the flat side.

The rust is foliicolous and occurs as tiny yellow specks. It can be detected only with difficulty amidst the sooty blotches of a Perisporiaceous fungus which occurs on the same host. Microtome sections through the sori indicate that the mycelium within the host is very coarse, and prior to the formation of the sorus (FIG. 1) large strands of fasciculate hyphae are grouped beneath the stoma and are up to 70–100 μ in diam. The guard cells become distended to such a great extent that the superstomal nature of the sorus in later stages becomes obscure, and appears like a subepidermal sorus with ruptured epidermis. The urediospores (FIGS. 2–6) are of various shapes but conform to the usual types met with in species of *Hemileia*.

Three species of *Hemileia* are known to occur on the members of the Asclepiadaceae, all of them being recorded from Africa. *Hemileia sonensis* Syd. (Sydow **1914**), described on an unidenti-



FIGS. 1–12. Noteworthy rusts.

fied member of the Asclepiadaceae, has urediospores measuring 22–32 × 18–25 μ, teliospores are unknown. *Hemileia Chlorocodonis* Syd., recorded on *Chlorocodon Wightii* (Sydow, H. & P. **1913**), has urediospores measuring 18–24 × 14–18 μ, whereas the urediospores of *H. scitula* Syd. (Sydow **1937**), on *Periploca* sp., measure 20–28 × 19–25 μ. From this it is clear that *Hemileia mysorensis* can be easily distinguished from all of these because of larger spores.

Mainsia Pterocarpi Thirumalachar sp. nov.

Uredia hypophylla raro amphigena, in infectionis maculis indistinctis, pallidis; intraepidermalia, lutea, erumpentis atque pulverulenta. Urediosporae subglobosae vel sphaericae, pallide luteae, singulis pediculis insidentes atque haud acervatae, 12.5–15 × 10–12.5 μ, episporio tenui, hyalino, minute atque dense echinulato. Telia minuta, evolventia ut crustae cereae atque urediis interspersa, intraepidermalia atque erumpentia, paraphysata, paraphysibus marginalibus atque incurvis; teliosporae hyalinae, pedicellatae, 4–6 sporis aggregatis super cellulam basalem sporogenam, cylindricae, in apice latiores quam in basi utroque apice rotundatae, germinantes per elongationem apicis sporarum in 4-cellulatum promycelium; 21–30 × 10–12.5 μ, episporium tenue hyalinum, leve.

Hab. in foliis *Pterocarpi marsupii*, Roxb. Balehonnur, Mysore, South India, 18–4–1942, leg. M. J. Thirumalachar. Typus lectus in Herb. Crypt. Ind. Orient., New Delhi, Arthur Herb., U. S. A., in Herb. I. M. I., Kew, Anglia.

Uredia hypophyllous rarely amphigenous, on pale indistinct infection spots, intraepidermal, yellow, erumpent and pulverulent; urediospores subglobose to spherical, pale yellow, borne singly on pedicels and not clustered, 12.5–15 × 10–12.5 μ. Telia minute, developed as waxy crusts and interspersed with uredia, intraepidermal and erumpent; paraphysate, paraphyses marginal and incurved; teliospores hyaline, one-celled, pedicellate, 4–6 spores in a cluster on a sporogenous basal cell, clavate to cylindric, broader at the apex than at the base, rounded at both ends, germinating by the prolongation of the spore apex into a four-celled promycelium, 21–30 × 10–12.5 μ; epispore thin, hyaline, smooth. Pedicel hyaline, deciduous.

Pterocarpus marsupium is an important timber tree in the forests of Mysore. The rust is foliicolous, and when present in abundance, causes severe defoliation of the shoots. Only uredia and telia, both of which are intraepidermal in origin, are known. There is no germ pore for the extrusion of the promycelium. The

teliospores of this rust resemble those in species of *Maravalia,* which includes several species like *M. pallida* Arth. & Thaxt., *M. achroa* (Syd.) Arth. & Cumm. on members of the Leguminosae. The telia are surrounded by a basket of paraphyses which are hyaline, marginal, incurved and possess a central hyaline core.

The genus *Mainsia* was established by Jackson (**1931**) to accommodate those rust species on *Rubus* which were characterized by the possession of one-celled hyaline pedicellate teliospores and which were originally included under *Spirechina.* This change was necessitated by the discovery that the type of *Spirechina, S. Loesneriana* (P. Henn.) Arth. was a species of *Kuehneola* having short chains of teliospores. Jackson further pointed out that the pycnia, aecia, uredia and telia are all intraepidermal, a distinguishing feature which separates it from the genus *Maravalia.* All the species of *Mainsia* so far recorded occur on *Rubus,* and because of this the conclusion has been drawn that the genus is limited to *Rubus.* The rust on *Pterocarpus marsupium* has uredia and telia developed in intraepidermal sori, with the teliospores resembling in structure and germination those of other species of *Mainsia.* The only point of contention against the inclusion of this rust under *Mainsia* might be that it parasitizes a member of the Leguminosae. It is true that certain rust genera like *Phragmidium* are solely restricted to members of the Rosaceae. However, many others like *Ravenelia,* which were originally considered to parasitize hosts belonging only to the families Euphorbiaceae and Leguminosae, have now been shown to occur on Tiliaceae also. The writer, therefore, considering the structure and development of the spore forms, is inclined to believe that the rust under consideration may be properly regarded as a species of *Mainsia.* Paraphyses have been recorded for some of the species of *Mainsia* also, like *M. Lagerheimii* (P. Magn.) Jackson & Holway.

Corbulopsora Cumminsii Thirumalachar sp. nov.

Uredia hypophylla, subepidermalia, minuta, citreo-lutea, paraphysata erumpentia atque pulverulenta, circumdata peridii vallo composito ex vallaribus cellulis quae lateraliter sunt unitae, in apice liberae, magnitudinis 105–112 × 6–10 μ, foramine in apice relicto ad liberationem sporarum; peridii cellulae crassis parietibus praeditae, in apice incrassatae. Urediosporae ovato-ellip-

soideae vel cylindricae, 25–36 × 14–21 μ, intus contentis citroluteis; episporium hyalinum, 3.5–5 μ crassum, dense foveolata; germinationis pori indistincti; paraphyses sporis associatae, tenuiter incurvatae, magnitudinis 40 × 4 μ. Teliosporae visae tantum in urediis veteribus, unicellulatae, pedicellatae, luteo-brunneae, oblongae, cylindricae, in apice rotundatae, leves, magnitudinis 30–40 × 14–22 μ.

Hab. in foliis *Lactucae runcinatae* DC. Hebbal, Bangalore, South India, 15–12–1944, leg. M. J. Thirumalachar. Typus positus in Herb. Crypt. Ind. Orient., New Delhi, Arthur Herb., U. S. A., in Herb. I. M. I., Kew, Anglia.

Uredia hypophyllous, subepidermal, minute, orange-yellow, paraphysate, erumpent and pulverulent, surrounded by a stockade of peridium composed of slender palisade-like cells which are united laterally and measure 105–112 × 6–10 μ leaving an aperture at the apex for the escape of the spores, cells of the peridium thick-walled and swollen at the tip. Urediospores ovate-ellipsoid to cylindric, 25–36 × 14–21 μ, with orange-yellow contents, membrane hyaline, 3.5–5 μ thick, deeply pitted, germ pores indistinct; paraphyses associated with the spores, slightly incurved, measuring 40 × 4 μ. Teliospores observed only within old uredia, one-celled, pedicellate, yellowish-brown, oblong-cylindrical, rounded at the apex, smooth, 30–40 × 14–22 μ.

The rust parasitizes the leaves of *Lactuca runcinata* forming pinkish-red infection spots. The uredia are subepidermal and the urediospores are borne singly on pedicels. The rust occurs all year in the uredial stage. Teliospores have been observed in very few cases and then only within old uredia. The stockade of palisade-like peridial cells (FIG. 9) around the telia and uredia, if present, is a distinguishing character of the genus. The two species of *Corbulopsora* described by Cummins (**1940**) from New Guinea occur on *Olearia*, a member of the Compositae. The present rust, which is also on a member of the Compositae, differs in spore measurements from the New Guinea species. The name *Corbulopsora Cumminsii* is proposed in honor of Dr. G. B. Cummins of Purdue University, U. S. A.

SCOPELLA FICI Mundkur & Thirumalachar. Occas. paper No. 16, I. M. I., England, p. 1–27. 1946.

A rust on *Ficus* sp. collected by the writer has recently been described by Mundkur and Thirumalachar (**1946**) as *Scopella Fici*. Only pycnia and telia were present in the type material.

The telial initials immediately follow the pycnia in development. The pycnia are subcuticular and the telia arise in orange-yellow waxy crusts bearing clusters of teliospores on sporogenous basal cells. Collections of the rust on the same host plant in different seasons revealed the presence of an uredial stage. Collections made in the months of February and March contained large numbers of uredia following the pycnia; the telia appear at a much later period. The development of a few teliospores within old uredia confirmed the genetic relationship of the spore forms. The development of either uredia or telia following the formation of pycnia indicates that *Scopella Fici* is one of the unstable rust forms with short-cycling tendencies, and adds another instance to those already described in detail by Jackson (**1931a**). *Scopella Fici* is therefore a brachy-form with subepidermal erumpent uredia, with urediospores developed in clusters of 8–16 on sporogenous basal cells. Mature spores are chocolate-brown, obovate-ellipsoid to pyriform (FIGS. 11–12), 31–45 × 25–35 μ, with two distinct germ pores at the base above the hilum. The wall is bilaminate; the inner one is smooth and golden-brown and the outer one is hyaline and shows echinulations.

Cerotelium Wagateae Thirumalachar & Gopalakrishnan, sp. nov.

Pycnia atque aecia ignota. Uredia minuta, hypophylla, dispersa, tenuiter brunnea, subepidermalia, erumpentia, hyphoides paraphysibus intus ad muros dispositis. Urediosporae sessiles, obovatae vel ellipsoideae, luteo-brunneae, tribus quattuorve germinationis poris instructae, magnitudinis 19–27 × 15–20 μ. Telia subepidermalia, minuta, urediis associata, initio lenticularia, postea erumpentia; teliosporae catenatae, lateraliter coalescentes, columnam in basi efformantes, in apice separatae atque pulverulentae atque in maturitate germinantes; sporae 4–6 in singulis catenis, sphericae vel angulariter globoideae, hyalinae, tenuiter parietatae, leves, magnitudinis 12–19 × 8–12 μ.

Hab. in foliis *Wagateae spicatae* Dalz., Balehonnur, Mysore, South India, 29-4-1945, leg. M. J. Thirumalachar (**Typus**), 12-3-1944 leg. K. S. Gopalakrishnan. Typus positus in Herb. Crypt. Ind. Orient., New Delhi, Arthur Herb., U. S. A., in Herb. I. M. I., Kew, Anglia (FIGS. 13–14).

Pycnia and aecia unknown. Uredia minute, hypophyllous, scattered, pale brown, subepidermal, erumpent, lined with hyphoid paraphyses. Urediospores sessile, obovate to ellipsoid, yellowish-brown, with three to four germ pores and measuring 19–27 × 15–20 μ. Telia subepidermal, minute, associated with uredia, lenticu-

lar in early stages, later on becoming erumpent; teliospores in chains showing lateral coalescence, forming a column at the base and becoming separated and pulverulent at the apex, 4–6 spores in a chain, spherical to angularly globoid, hyaline, thin-walled, smooth, 12–19 × 8–12 μ, germinating at maturity.

The leaf rust on *Wagatea spicata*, a member of the Leguminosae, has on examination proved to be an undescribed species of *Cerotelium*. It differs from *Cerotelium morobeanum* Cummins on *Derris* sp. (Cummins **1941**) and other species on Leguminosae in the size of the spores. The rust pustules are very minute and can hardly be seen in the field. No other species of *Cerotelium* on Leguminosae has so far been recorded from India.

PUCCINIA BOTTOMLEYAE Doidge. Bothalia **3**: 498. 1939.

Hab. on the leaves and inflorescence of *Aristida depressa* Retz., Hebbal, Bangalore, South India, 2–3–1945, leg. M. J. Thirumalachar.

Aristida depressa is a common weed grass in the dry farm lands of Bangalore. The rust attacks the leaves and the inflorescence forming characteristic pulvinate black sori. The uredia are epiphyllous and also distributed on the inflorescence. They are covered by the epidermis in the early stages. The urediospores are subglobose to spherical, cinnamon-brown and measure 21–28 × 20–24 μ; the epispore is hyaline, 2 μ thick, and densely verruculose. There are 8–11 scattered germ pores. The telia are at first covered over by the epidermis but later become naked and pulvinate, appearing as black crusts up to 1 mm. long. The teliospores are ovate to subglobose and rounded at both ends, chestnut-brown, smooth and measure 30–35 × 20–25 μ. The spores are not constricted at the septa and the walls are thick with the apex thickened up to 6 μ. The pedicels are up to 125 μ long, hyaline, persistent, and sometimes obliquely inserted. The telia possess numerous capitate, hyaline to fuscous paraphyses which measure about 112 μ long and 20 μ at the bulged capitate portion.

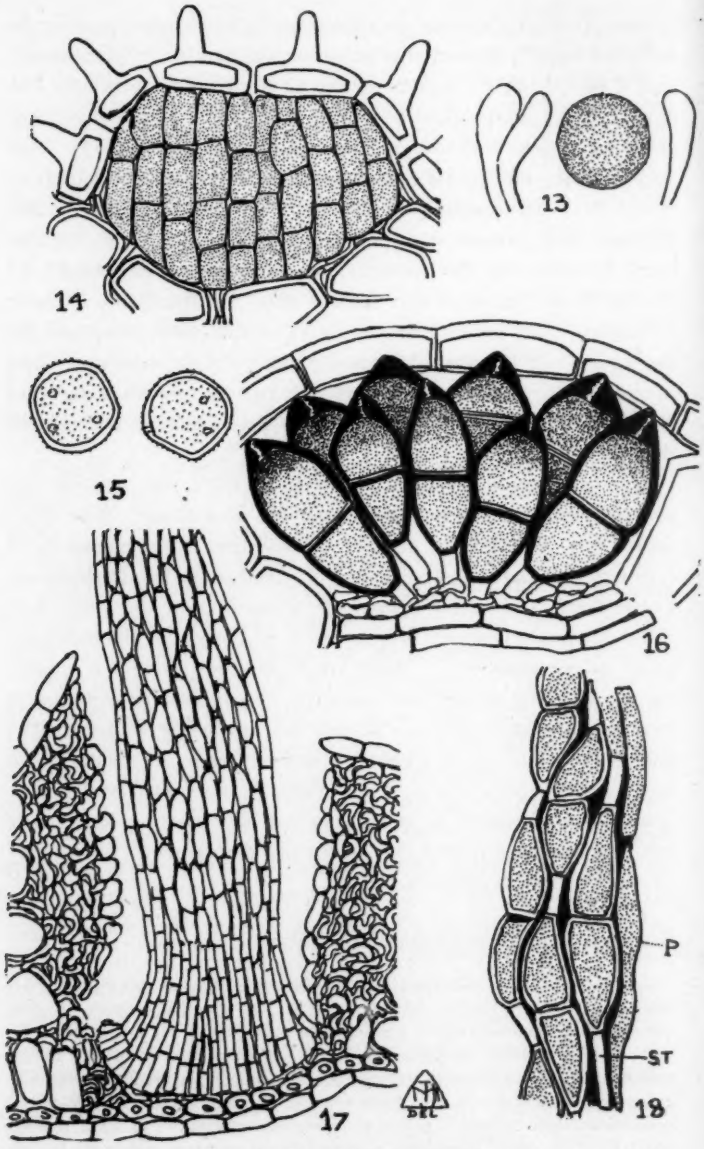
The crustose pulvinate nature of the telia distributed on the inflorescence immediately brings to mind that the rust might be closely related to *P. Eylesii* described by Doidge from South

Africa (**1926**). *Puccinia Aristidicola* which is known to occur in India is clearly a distinct rust possessing striate sori. The present rust differs from *P. Eylesii* in having a paraphysate telium and much broader urediospores. On the other hand, it resembles very closely *Puccinia Bottomleyae* described by Doidge (**1939**) from South Africa on *Aristida adscensionis, A. Welwitschiae* and *A. barbicollis*. The urediospores of this rust measure 22–30 × 20–25 μ and thus compare favorably with 21–28 × 20–24 μ in the material collected by the writer. The germ pores are stated by Doidge to be scattered and from 4 to 7 for the South African collections, whereas they are up to 11 in the collections made by the writer. In the size, shape and structure of the teliospores and in possessing capitate paraphyses the rust on *Aristida depressa* closely resembles *P. Bottomleyae* and there is very little doubt that the two belong to a single species.

A morphological study of the sorus indicated that the telia are subepidermal and deep-seated within the host tissue. The teliospores are developed in clusters on indistinct sporogenous basal cells which are laterally free and firmly fixed to the basal hymenium. Consequently, when the spores are scraped from the spore bed, the clusters of teliospores are carried over along with the mutilated basal sporogenous cell. There are 8–10 teliospores in a cluster, the spores being of different maturity. Such clustered teliospores have been demonstrated in *Puccinia Solmsii* by the writer (**1945**) and Kuhnholtz-Lordat (**1944**) described them in a number of species of *Puccinia* like *P. Cynodontis, P. Polygonii*, and others. This clustered nature by itself may not have generic significance but only indicates one of the modes of development (fasciculate) as described by Kuhnholtz-Lordat.

Puccinia Bulbostylidicola Thirumalachar sp. nov.

Uredia hypophylla, distributa super pedunculos, lincaria vel elliptica, 1–2 mm. longa, subepidermalia, erumpentia atque pulverulenta, brunnea, in statu initiali cooperata epidermate; urediosporae subglobosae vel ellipsoideae, 18–21 × 11–19 μ, tenuiter parietatae (1–1.5 μ), in apice haud incrassate minute verruculosae, tribus dispersis germinationis poris. Telia urediis similia, distributa per pedunculos, nigra, haud erumpentia; teliosporae ellipsoideae vel cylindricae, luteo-brunneae, colore aliquantulum profundiore in apice, tenuiter constrictae ad septa, lateralibus angularibus ob mutuam compressionem in



FIGS. 13–18. Noteworthy rusts.

soro ipso, leves, 31–55 × 14–23 μ, in apice incrassatae ad 6 μ. Mesosporae plures, magnitudinis 25–35 × 12–20 μ. Pediculis hyalinis, persistentibus, 25–30 μ longis.

Hab. in foliis et pedunculis *Bulbostylidis barbatae* Kunth., Hebbal, Bangalore, South India, 8-1-1945, leg. M. J. Thirumalachar. Typus positus in Herb. Crypt. Ind. Orient., New Delhi, Arthur Herb., U. S. A., in Herb. I. M. I., Kew, Anglia (FIGS. 15–16).

Uredia hypophyllous, distributed on the peduncles, linear to elliptic, 1 to 2 mm. long, subepidermal, erumpent and pulverulent, chocolate-brown, covered by the epidermis in the early stages; urediospores subglobose to ellipsoid, 18–21 × 11–19 μ, thin walled (1–1.5 μ), not thickened at the apex, minutely verruculose, with three scattered germ pores. Telia similar to uredia, distributed on the peduncles, black, non-erumpent, teliospores ellipsoid to cylindric, yellowish-brown, with a deeper shade towards the apex, slightly constricted at the septa, sides angular on account of mutual compression within the sorus, smooth, 31–55 × 14–23 μ, thickened at the apex up to 6 μ. Mesospores numerous, measuring 25–35 × 12–20 μ. Pedicels hyaline, persistent, up to 25–30 μ long.

When the first collections of the rust were made, only telia were present in large numbers. A comparative study indicated that the telia of the rust closely resembled *P. Bulbostylidis* Doidge recorded by Doidge (**1926**) from South Africa on *Bulbostylis Burchelli*. The teliospores in this rust measure 33–60 × 13–19 μ and thus compare very favorably with 31–55 × 14–23 μ, which denotes the size of the teliospores in the rust under study. But the urediospores in the two rusts show characteristic differences. In *P. Bulbostylidis* according to Doidge, they are golden-brown and measure 16–20 × 21–28 μ and therefore are very much broader than those of the present rust in which they are only 18–21 × 11–19 μ. Further, the spores are thick-walled (3–3.5 μ) with three equatorial germ pores in *P. Bulbostylidis*, whereas they are much thinner (1.5 μ) in the present rust, the germ pores being scattered and not equatorial. The two rusts can therefore be differentiated by the structure and size of the urediospores.

PUCCINIA EXHAURIENS Thüm. Flora **1876**, p. 425, Sydow Monogr. Ured. I, p. 344.

On the leaves of *Jasminum* sp., Nalur, Thirthahalli, Mysore, 4–4–1945, leg. M. J. Thirumalachar, Balehonnur, Mysore, 15–6–1945, leg. K. S. Gopalakrishnan.

This rust is known to occur on *Jasminum tortuosum* in South Africa. A detailed study of it has indicated that it is a microcyclic rust consistently lacking pycnia.

PUCCINIA OAHUENSIS E. & E. Bull. Torrey Club **22**: 435. 1895. (*Uredo Digitariaecola* Thüm. Myc. Univ. No. 2041, 1882; *Puccinia Digitariae* Pole Evans. Ann. Bolus Herb. **2**: 111. 1917.)

On the leaves of *Digitaria marginata* Link. Hebbal, Bangalore, 19–1–1945, leg. M. J. Thirumalachar. The rust was described by Pole Evans from South Africa as *P. Digitariae* and was known by that name until recently when Cummins (**1943**) pointed out that *Puccinia oahuensis*, described by Ellis and Everhart in 1895, is the same rust and thereby reduced *P. Digitariae* to synonymy. Though this rust has not been recorded for India by Butler and Bisby (**1931**) or Mundkur (**1938**), a collection was made in India and distributed in Sydow Ured. *2272*, which is quoted by Cummins (**1943**). An account of the measurements of the urediospores and teliospores based upon numerous collections is given by Cummins and those of the rust collected by the writer on *Digitaria marginata* agree with them in all respects. The measurements obtained by the writer are II: 25–31 × 20–25 μ, and III: 35–50 × 20–27 μ. The urediospores possess three to four scattered germ pores and not equatorial ones as described for *P. oahuensis*. Such a feature has been noticed by Cummins also in a collection of the rust on *D. scalarum* made by Hansford in Uganda and Cummins considers that it may only be a variant of *P. oahuensis*.

PUCCINIA PHYLLOCLADIAE Cke. *in* Grevillea **10**: 125. 1882. Syd. Monogr. Ured. **I**, 612. Doidge, Bothalia **2**: 111–112. 1926.

On the cladodes of *Asparagus* sp., Korekote, Thirthahalli, Mysore, 4–4–1945, leg. M. J. Thirumalachar, Balehonnur, Mysore, South India, 15–6–1945, leg. K. S. Gopalakrishnan.

A rust parasitizing the cladodes of *Asparagus* in Mysore compared very favorably with *Puccinia Phyllocladiae* Cke. which is known to occur in South Africa on *Asparagus falcatus*. The telia are amphigenous, subepidermal and form dull brown sori. The

teliospores are broadly ovate, yellowish-brown, not constricted at the septa and measure 34–42 × 25–35 μ. The measurement given by Doidge for the South African collections is 32–45 × 30–40 μ. The pedicels are often obliquely inserted and the germ pore in the upper cell is not apical but is shifted to one side. In all these essential features the rust on *Asparagus* collected by the writer resembles the descriptions of *P. Phyllocladiae* given by Doidge (**1926**).

Although no spore form other than telia is known for the rust, abundant uredia are present in the writer's collection. These are developed early in the season and are replaced by telia later on. They are borne on the same mycelium as the telia. The association of some urediospores within some telia confirms beyond doubt the genetic relationship between the two spore forms. The uredia are amphigenous, subepidermal, erumpent and pulverulent, chocolate-brown and associated with a few clavate paraphyses. Urediospores are pedicellate, ovate-ellipsoid to obovate, golden-yellow with a brownish tinge, have 5–6 equatorial germ pores and measure 26–38 × 19–22 μ. The epispore is thin-walled and densely verruculose. The spores readily germinate when placed in moist chambers, and develop long germ tubes.

PUCCINIA SHIRAIANA Syd. Hedwigia **1899**, p. 141. Sydow Monogr. Ured. **I**, 232.

Hab. on the leaves and petioles of *Justicia* sp., Balehonnur, Mysore, South India, 29–4–1945, leg. M. J. Thirumalachar, Lakkavalli, Mysore, 14–10–1945, leg. Thirumalachar. The rust collected on *Justicia* (*tomentosa?*) has only telia, hypophyllous and often distributed on the petioles as black crusts. *Puccinia peraffinis* Syd. on *Justicia diffusa* and *Puccinia Thwaitesii* B. & Br. on *J. gendurosa* also occur in Mysore and these are autoecious species. Sydow and Petrak (**1931**) record this rust from the Philippines on *J. procumbens*.

STRUCTURE OF THE TELIUM IN GAMBLEOLA CORNUTA MASSEE

Gambleola cornuta is a monotypic genus producing long blackish spore tendrils on the leaves of *Berberis nepalensis*. The type

of the genus was collected by Dr. Gamble near Chakrata, Upper India and is found to be well distributed on the hill tops. In an account of the evolutionary tendencies and the origin of the life-cycles in rusts, Jackson (**1931**) gives a vivid account of the derivation of microcyclic rusts like *Didymopsora, Gambleola, Pucciniosira* and others from *Endophyllum*-like forms, possibly by the lateral coalescence of the spore chains. He cites as evidence the presence of the peridium in the telium of *Pucciniosira* and *Gambleola,* and the occurrence of distinct sterile intercalary cells between the fertile spores in all these genera. These morphological features (*i.e.,* the presence of a peridium and sterile intercalary cells), Jackson points out, do not appear to have been noted in this genus previously. However, it might be pointed out that the presence of an outermost layer of sterile cells (though not termed as the peridium) binding the spore chains is described in the telial column of *Gambleola* (Dietel **1928**).

Large quantities of the material of *G. cornuta* were collected by the writer in the Kodiakanal Hills, South India. This made possible a detailed morphological study which adds further confirmatory evidence to Jackson's findings. Although a pycnial stage for the rust is described for the genus by Massee, no pycnia were seen to accompany the telia in my material. The telial initials are organized beneath the epidermis by the formation of a plectenchyma composed of coarse hyphal strands. A palisade layer of basal cells is differentiated. These cells abstrict, in succession, a large number of rectangular, thin-walled, spore mother cells which coalesce laterally to form a columnar structure. As the development of the spore column is towards the lower epidermis, the sorus appears cupulate and deep-seated, bordered by globoid hyphal cells, which however do not become papillate as in *Masseeella* (FIG.17). Each spore mother cell cuts off an intercalary cell and a teliospore initial which becomes two-celled and *Puccinia*-like, following one more division. The outermost layer of spore mother cells remains one-celled and constitutes the peridium (FIG. 18). On account of the lateral adherence of the spore chains, long spore columns are produced. The sterile intercalary cells do not function as disjunctor cells, but only serve to point out the relationships of microcyclic rusts like *Gambleola* with *Endophyllum*-like forms.

PHAKOPSORA TECTA Jackson & Holway, Mycologia **18**: 148–149, 1926.

Hab. on the leaves of *Commelina* sp., Bangalore, South India, 22–12–1944, leg. M. J. Thirumalachar. Jackson and Holway (**1926**) described *Phakopsora tecta* on *Commelina quitensis* from Bolivia, South America. Petrak and Ciferri (**1932**) recorded it for the Dominican Republic. Although species of *Uromyces* are present in India on members of the Commelinaceae, *Phakopsora tecta* is being reported only from the present collection as it was not included in a recent review of the genus *Phakopsora* by Mundkur (**1943**). The uredia are characteristically different from those of other rusts on *Commelina* in that they possess a membranous peridium formed by the union of bases of incurved capitate paraphyses. A small pore is formed at the apex for the escape of the spores. The urediospores are hyaline, ovate-ellipsoid, and finely verruculose to echinulate. The infestation of *Phyllosticta Uredinicola* brings about the deterioration of the spores and the ultimate collapse of the sorus. Unlike some other uredinicolous fungi, *Phyllosticta Uredinicola* develops within the centre of the sorus and arrests further development of the spores.

Aecidium Memecyli Thirumalachar sp. nov.

Infectionem systemican novorum surculorum causat. Pycnia amphigena, melleo-lutea, parva, subepidermalia, applanata, ostiolata, paraphysibus ostiolaribus. Aecia subepidermalia, erumpentia, pulverulentia, cupulata, alba, peridiis bene evolutis; peridii cellulae globosae vel angulares, crassis parietibus praeditae in lateribus conterminis, striatae, magnitudinis 18–31 × 15–20 μ. Aeciosporae angulariter globoideae ob compressionem, hyalinae, tenuiter parietatae, minute atque dense verruculosae, magnitudinis 19–24 × 14–21 μ.

Hab. in *Memecyli* specie (*umbellati*?), Nandi Hills, Mysore, South India, 15–7–1945, leg. H. C. Govindu. Typus lectus in Herb. Crypt. Ind., Orient., New Delhi, Arthur Herb., U. S. A., in Herb. I. M. I., Kew, Anglia.

Causing the systemic infection of the young shoots; pycnia amphigenous, honey-yellow, small, subepidermal, applanate, ostiolate with ostiolar paraphyses. Aecia subepidermal, erumpent and pulverulent, cupulate, white, with well developed peridia; peridial cells angular to globoid, thick-walled on the abutting sides, striate, 18–31 × 15–20 μ; aeciospores angularly globoid due to compression, hyaline, thin-walled, minute and densely verruculose, measuring 19–24 × 14–21 μ.

The rust causes systemic infection of the young shoots developing in the axils. As these unfold, a malformed witches'-broom-like structure completely studded with pycnia and later on by aecia is formed. The rust differs from any of the other *Aecidium* and aecial stages of rusts recorded on the members of the Melastomaceae.

UREDO CELASTRI Arthur & Cummins, Philippine Jour. Sci. **61**: 463–488, 1936.

Hab. on the leaves of *Celastrus paniculata* Willd., Nandi Hills, Mysore, South India, 29–4–1945, leg. M. J. Thirumalachar.

A rust on *Celastrus paniculata* Willd. was collected by the writer in Nandi Hills which appeared to be identical with *Uredo Celastri* described by Arthur and Cummins (**1936**) from the Philippines. The rust is hypophyllous, minute, golden-yellow when fresh and turning yellowish-brown on drying up. The uredia are subepidermal, erumpent and paraphysate; the urediospores ovate-ellipsoid, cinnamon-yellow and distinctly echinulate. There are 5 or rarely 6 scattered germ pores. The complete absence of any peridium indicates that the rust is not congeneric with *Pucciniastrum Celastri* Syd. described by Sydow and Butler (**1907**) on *Celastrus* from the Himalayas. The urediospores, in the material collected by the writer, measure 22–26 × 22–30 μ and are therefore slightly narrower than the measurements given by Arthur and Cummins for *U. Celastri* (22–27 × 28–34 μ). But for this minor variation, the present rust agrees with *U. Celastri.*

UREDO CHASALIAE Petch, Ann. Roy. Bot. Gard. Peradeniya **iv**, pt. v, p. 303, 1909. Sacc. Syll. Fung. **21**: 798.

Hab. on the leaves of *Chasalia curviflora* Thw., Balehonnur, Mysore, South India, 28–4–1945, leg. M. J. Thirumalachar, leg. K. S. Gopalakrishnan, 12–2–1945. The rust was described by Petch in Ceylon on the same host species.

UREDO OPHIORRHIZAE Petch. Ann. Roy. Bot. Gard. Peradeniya, **vi**: 212, 218, 1917. Sacc. Syll. Fung. **23**: 945.

Hab. on the leaves of *Ophiorrhiza Brunonis* W. & A., Kemmangundi, Mysore, South India, 10–8–1945, leg. H. C. Govindu, and Balehonnur, Mysore, 12–1–1946, leg. K. S. Gopalakrishnan.

In conclusion, the writer wishes to acknowledge his deep sense of gratitude to Dr. G. B. Cummins, Purdue University, Lafayette, Ind., U.S.A., for the benefit of many valuable suggestions, and to Dr. L. N. Rao, Central College, Bangalore, for kind encouragement. Grateful thanks are due to Rev. Dr. H. Santapau, Ph.D., S. J., Professor of Botany, St. Xavier's college, Bombay, for kindly translating to Latin the diagnoses of the new species.

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EXPLANATION OF FIGURES

FIG. 1: Uredium of *Hemileia mysorensis*, × 300. FIGS. 2–6: Urediospores of *H. mysorensis*, × 900. FIG. 7: Telium with germinating teliospores of *Mainsia Pterocarpi*, × 400. FIG. 8: Urediospores of *M. Pterocarpi*, × 800. FIG. 9: Portion of the peridium of *Corbulopsora Cumminsii*, × 450. FIG. 10: Urediospore of *C. Cumminsii* showing the pitted wall, × 900. FIGS. 11–12: Urediospores of *Scopella Fici*, × 900. FIG. 13: Urediospore and the portion of the hyphoid paraphyses of *Cerotelium Wagateae*, × 900. FIG. 14: Telium of *C. Wagateae*, × 400. FIG. 15: Urediospores of *Puccinia Bulbostylidicola*, × 800. FIG. 16: Telium of *P. Bulbostylidicola*, × 800. FIG. 17: Section through the telium of *Gambleola cornuta*, × 200. FIG. 18: Portion of the telial column enlarged showing 'P' = peridium and 'St' = sterile intercalary cell, × 900.

NOTES AND BRIEF ARTICLES

Lohwag's Anatomie der Asco- und Basidiomyceten

It seems desirable to call attention to an authoritative and exhaustive work by the late Professor H. Lohwag, of the University of Vienna, entitled *Anatomie der Asco- und Basidiomyceten,* published in 1941 shortly before this country was drawn into war. Very few copies reached the United States and since the publisher was Borntraeger Bros. of Berlin it is reasonable to suppose that the publisher's stock has been destroyed. This work covers 529 pages of text with the addition of an extensive list of literature of more than 900 titles reviewed by the author and covering the period between 1601 and 1940. The 348 text figures add greatly to the value of the book. An index of more than 600 terms increases the current mycological vocabulary as found in Snell's *Three Thousand Mycological Terms.* It was issued as Band VI, Abteilung II, Teilband 3, C of the general series entitled *Handbuch der Pflanzenanatomie* under the editorship of the late Prof. K. Linsbauer. It may be noted in passing that presumably reliable reports are to the effect that Prof. Lohwag died of starvation in Vienna shortly after the end of the war in Europe.

The book is divided into twelve chapters based upon the Haberlandt system of physiological plant anatomy. Certain types of hyphae figure prominently in more than one of these chapters indicating the several types of anatomic function one hypha can have during its development from initiation in mycelium or fructification to maturity. A large mass of data has been brought together, much of it substantiated by only one description, one report, one experiment, or one histological study. Frequently throughout the work it is pointed out that additional research on certain topics may or will change the concept of discussed anatomic or physiologic-anatomic functions. Also, it is frequently evident that the author is treading, or regards himself as treading, on thin ice in respect to his knowledge of certain structures, and in respect to

his interpretation of the knowledge of others concerning those or other structures. The book poses many problems for solution in the future by mycologists interested in anatomy, physiology or physiological anatomy. Although most of the book centers around the role played by individual hyphae in the mycelium or fructification, specific discussions of such structures as rhizomorphs, as found in *Armillaria, Merulius* and other basidiomycetous as well as ascomycetous fungi, and sclerotia, as found in *Typhula, Sclerotinia* and other basidiomycetous and ascomycetous fungi, are most interesting and present many problems.

An excellent translation has been made of Lohwag's volume by Wm. Bridge Cooke and Henry Q. Middendorf which will make it much more readily available to those who lack the time or inclination to delve into the intricacies of Lohwag's scientific German. Copies have been deposited in the library of the United States Department of Agriculture, which was the source of the original from which Mr. Cooke and Mr. Middendorf made their translation, in the Mycological Collections of the Bureau of Plant Industry at Beltsville, Maryland, and in the Lloyd Library, Cincinnati, Ohio. Without the assistance of Mr. Middendorf, Instructor in German at Brooklyn Polytechnic Institute, who was serving in the same U. S. Army Signal Corps camp with Mr. Cooke, the project could not have been completed.—JOHN A. STEVENSON.

THE POLYPORACEAE OF NEW YORK STATE

(THE GENUS PORIA)

This paper is a completion of the author's previous study of the New York State Flora of the fungi belonging to this family. The bulletin consists of 91 pages and includes keys and descriptions of 82 species of *Poria,* a glossary of terms, and an index. Under each species the more important taxonomic literature is cited, followed by an extensive description and taxonomic notes, and closing with pathological information, when known. There are 20 figures of line drawings. The bulletin may be obtained from the Extension Department of the New York State College of Forestry, Syracuse 10, N. Y., at the actual cost of printing, 60 cents per copy.—B. B. KANOUSE.

RED FLY-AGARIC IN FLORIDA

Amanita muscaria L. is usually red or reddish in Europe and yellow in America. On Dec. 22, 1945, a colony of red plants, ten in number, was found near Gainesville by Marjorie Gratz in low mixed woods with sweetgum, oak, pine, etc. There was no variation in the color of these hymenophores; all were pure-red (*ruber*), shining, with a few cream patches, mostly about the margin, which was striate in the older specimens. In size, shape and other characters the plants were a good match for Bresadola's colored plate 8 in his Iconographia Mycologica. The yellow form of the species is rare about Gainesville, in pine woods. So far as I know, the red form has not previously been reported from Florida.—W. A. MURRILL.

FOMES FRAXINEUS IN FLORIDA

This rare species was collected Aug. 11, 1946, in quantity on a diseased laurel oak trunk in Gainesville, where I had been watching it for three years. I had formerly found small, unsatisfactory specimens west of Gainesville on southern hackberry and near Orange Springs, in Marion Co., on willow. Overholts reported it from the state without mentioning the locality. The fresh hymenophores have a strong and very pleasing anise odor.—W. A. MURRILL.

SPECIMENS WANTED

Miss E. E. Morse is doing research on puffballs with embossed peridia. The bumps ("bosses") vary much in size and aspect. She finds that they have been collected in many localities since 1885, and that they were named *Lycoperdon lepidophorum* by Ellis. An approved present day name is *Calvatia lepidophora* (Ellis) Lloyd.

Miss Morse would be glad to receive specimens at the Life Sciences Bldg., Univ. of Calif., Berkeley 5, California.—A. H. S.